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NUMERICAL SIMULATION OF OIL MIGRATION THROUGH A LENTICULAR RESERVOIR

BY

BENJAMIN JAY ROSTRON

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF SCIENCE

DEPARTMENT OF GEOLOGY

EDMONTON, ALBERTA
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ABSTRACT

Highly-permeable sandstone bodies are favorable sites for hydrocarbon accumulation. Oil entrapment in these highly permeable reservoirs is controlled by fluid-potential conditions that exist in and around the accumulation sites. Previous analyses of fluid-potential distributions have been useful for hydrocarbon exploration purposes.

The evolution of the oil and water fluid-potential fields during oil emplacement in a lenticular reservoir is studied using numerical simulations of oil migration. A two dimensional, two phase, finite-difference flow model: SWANFLOW-2D, and the University of Calgary's Cyber 205 supercomputer are used, with an input data set representing a reservoir from the Belly River Formation, in west-central Alberta.

Results show that fluid flow directions and oil entrapment within a reservoir are controlled by regional fluid-potential gradients that are modified by three effects, namely: (1) highly permeable lenses; (2) buoyancy; and (3) capillary forces. The distribution of fluid-potentials is genetically related to oil saturation through capillary pressure and relative permeability curves. As migration and entrapment proceed, oil saturation distribution, and thus fluid-potential distributions change in space and time.

This study extends previous fluid-potential based exploration methods by accounting for oil and the presence

of capillary forces within the flow domain, enabling a better understanding of the process of oil migration and entrapment in lenticular reservoirs.

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The members of my advisory committee: Dr. H-G Machel; Dr. H.A.K. Charlesworth; and Dr. S.M. Farouq Ali, reviewed and provided valuable input into this thesis.

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The support provided by my wife Catherine throughout this work has been immeasurable. She has been with me when times were good, when times were bad, and when we were far apart. I could not have done this without her.

Thank you all.

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1.0 INTRODUCTION

1.1 Background

A highly-permeable lenticular reservoir situated in a uniform field of formation-fluid flow will cause characteristic perturbations in that flow field (Obdam and Veling, 1987; Tóth and Rakhit, 1988). These perturbations have been shown to be field-mappable in some cases, and can thus be useful in the exploration for stratigraphically trapped oil and gas reservoirs.

This exploration technique evolved from an early study of potentiometric distortions caused by a lens-shaped sand aquifer (Tóth, 1962). At that time, the phenomenon was recognized theoretically for groundwater flowing through sand bodies and applied empirically as an exploration technique for groundwater supplies (Tóth, 1966). Further theoretical development by Tóth and his co-workers led to the development of an oil/gas exploration technique based on detailed potentiometric surface analysis (Rakhit, 1987; Parks and Tóth, 1988; Tóth and Rakhit, 1988).

Although other examples of the use of potentiometric surface analysis for hydrocarbon exploration exist, (Zawisa, 1986; Vugrinovich, 1988; Wells, 1988) they focus on regional flow patterns rather than localized potentiometric perturbations. The aforementioned studies have dealt with single-phase (water) fluid flow only, having assumed that the highly-permeable rock bodies are the most favorable sites for hydrocarbon accumulations. As such, the single phase, potentiometric-surface exploration technique was utilized to locate reservoir-quality rock bodies rather than oil filled reservoirs.

In these previous works no consideration was made of the presence of an oil (or gas) phase, and the resulting reduction in relative permeability to water. The possibility exists that a lowered permeability to water (resulting from increased hydrocarbon saturation) may mask the highly-permeable lens effect and/or distort the water flow pattern.

Furthermore, single phase, potentiometric-surface analysis does not account for capillary forces which are important, and possibly controlling, factors in hydrocarbon migration and emplacement (Davis, 1987; Jennings, 1987).

This study investigates the effects of oil on the water and oil fluid-potential surfaces, including capillary pressures in the porous media. Results were obtained by numerical simulations of oil migration/emplacement in a lenticular reservoir.

1.2 Objectives

This work has three major objectives: 1) to simulate transient oil emplacement in a lenticular reservoir; 2) to study the evolution of oil and water potentiometric surfaces during emplacement, with emphasis on the effects of the degree and distribution of oil saturation; and 3) to improve the technique of potentiometric surface analysis by including capillary forces, and considering the presence of a second (oil) fluid phase.

2.0 POTENTIOMETRIC SURFACE EFFECTS

2.1 Fluid-Potential Equations

The fluid potential, Φ, as defined by Hubbert (1940) is used to analyze subsurface fluid flow. Hubbert defined the fluid potential as the total mechanical energy per unit mass of fluid, at any point in the flow domain. The relationship between fluid potential, fluid pressure, fluid density, and position is given by:

$$\Phi = gz + \frac{p}{\rho} \tag{2.1}$$

where: Φ : fluid potential $[L^2/T^2]$; g : gravitational constant $[L/T^2]$; z : elevation of point of measurement above a common datum (sea level) $[L]$; p : fluid pressure (gage) $[M/L \cdot T^2]$; ρ : fluid density $[M/L^3]$.

Thus defined, values of fluid potential describe an energy field where flow is from areas of higher, to lower potential.

The fluid potential may be represented as an equivalent column of fluid or "hydraulic head", h. Hydraulic head is proportional to fluid potential, indicating the mechanical energy per unit weight of fluid. Equation 2.2 expresses the relationship between hydraulic head and fluid potential as:

$$h = \frac{\Phi}{g} \tag{2.2}$$

where: h : hydraulic head [L].

The hydraulic head equation is written as:

$$h = z + \frac{p}{\rho g} \tag{2.3}$$

Values of hydraulic head calculated for an entire formation define an imaginary energy surface termed the potentiometric surface (Figure 2.1). Fluid flows from D (higher hydraulic head) towards A (lower hydraulic head).

Fluid flow rate is related to the gradient of the fluid's energy field through the empirically established Darcy's Law, which can be stated as:

$$q = -\frac{k \rho g a}{\mu} \frac{\partial h}{\partial l} \tag{2.4}$$

where: q : flow rate [L^3/T]; k : intrinsic permeability of the porous medium [L^2]; μ : fluid dynamic viscosity [M/LT]; $\frac{\partial h}{\partial l}$: gradient of the hydraulic head field in the direction l [L/L]; and a : cross-sectional area [L^2].

In the case where two (or more) immiscible fluids are present, each will have its own energy- and resulting flow-field, given by the multiphase form of Darcy's Law:

$$q_f = -\frac{k k_{rf} \rho_f g a}{\mu_f} \frac{\partial h_f}{\partial l} \tag{2.5}$$

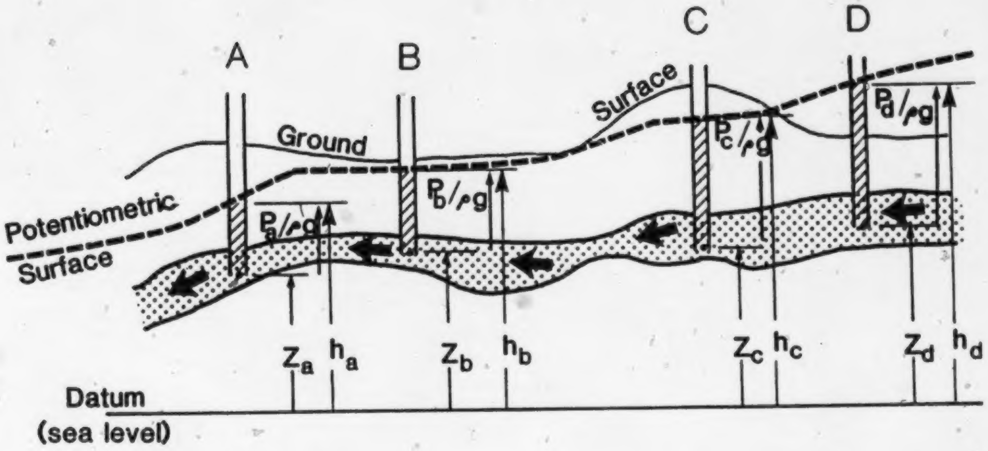

A
B
C
D
Ground
Surface
Potentiometric
Surface
$P_a/\rho g$
$P_b/\rho g$
$P_c/\rho g$
$P_d/\rho g$
Z_a
h_a
Z_b
h_b
Z_c
h_c
Z_d
h_d
Datum
(sea level)

Figure 2.1: Relationship between: hydraulic head; position; the potentiometric surface; and flow direction in a subsurface environment (modified from Dahlberg, 1982).

where: k_r : relative permeability (a function of fluid saturation); and where the subscripts refer to the property of each particular fluid f .

With two or more fluid phases present there is a pressure difference across their mutual boundaries, caused by interfacial tension between them (Berg, 1975; Dullien, 1979). The magnitude of this pressure difference is given by the Young-Laplace Equation of Capillarity (Dullien, 1979), stated as:

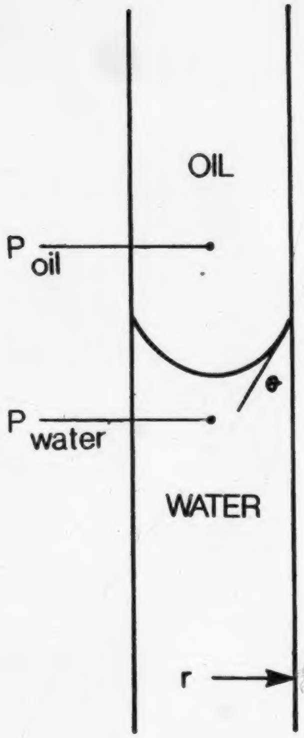
$$p_c = \frac{2\gamma\cos\theta}{r} \qquad (2.6)$$

where: p_c : capillary pressure difference $[M/LT^2]$; γ :interfacial tension $[M/T^2]$; θ : contact angle between the fluids $[L^0]$; r : radius of the pore throats in the rock [L].

The relationship between P_c, θ, and r, for a water-wet oil/water system is shown in Figure 2.2. By definition, water-wet rocks are those that have contact angles (measured in the denser phase) less than 90 degrees.

Most rocks do not contain uniform pore-throat distributions, thus equation 2.6 is not widely applied to rocks. Instead, capillary pressure relationships are determined experimentally. This topic will be discussed further in section 4.3.

By convention, the magnitude of the pressure difference for water-wet rocks is given by:


OIL
P oil
P water
WATER
r

$$P_C = P_{oil} - P_{water}$$

Figure 2.2: Relationship between capillary pressure difference(P_o-P_w); contact angle; and tube radius for a simple water-wet oil/water system.

$$p_c = p_o - p_w \tag{2.7}$$

where: p_o : experimentally measured oil-phase pressure $[M/LT^2]$; p_w : experimentally measured water-phase pressure $[M/LT^2]$.

2.2 UVZ Method

Possibly the earliest, and now the most widespread application of potential field theory to hydrocarbon exploration was presented by Hubbert (1953). In that work, Hubbert outlined his now famous UVZ method.

Briefly, the UVZ method consists of the graphical construction of three (U, V, Z) surfaces, which are defined (Hubbert, 1953) as:

$$U = \frac{\rho_o}{(\rho_w - \rho_o)} h_o \tag{2.8}$$

$$V = \frac{\rho_w}{(\rho_w - \rho_o)} h_w \tag{2.9}$$

$$Z = Z \tag{2.10}$$

where: U : oil hydraulic head surface, modified by a density factor; V : water hydraulic head surface, modified by a density factor; and Z : elevation with respect to a common datum.

It is apparent from equations 2.8 and 2.9 that fluids of different density will possess, and act under, their own mechanical energy fields. This occurs whether or not the particular fluid is physically present in space. This concept was applied to the exploration for oil and gas in hydrodynamic environments by the illustration of the relationship between their fluid-potential fields. Each fluid will tend to flow towards its respective potential minimum. Positions of low, and/or closed minima were shown to be favorable locations of hydrocarbons (Hubbert, 1953; Dahlberg, 1982).

The method can be summarized in four steps. First, the Z surface is specified as the impermeable structural top of the prospective horizon, and is contoured. Second, the distribution of water hydraulic head is determined (using equation 2.3) from pressure data obtained from Drill Stem Tests (DSTs), and/or water level measurements. Third, the V surface is calculated by using the expected hydrocarbon density, and applying equation 2.9 to each point in the flow domain. Finally, the U surface is calculated by subtracting the Z surface from the V surface.

The U surface represents the fluid-potential field for the hydrocarbon phase. Hydrocarbons move towards, but are unable to exit from, localized minima on this surface. Such areas are potential traps. In this manner, the location of prospective hydrocarbon deposits can be determined, based on an analysis of the formation-fluid hydraulic head distribution.

The UVZ method has three limitations/disadvantages:

1) It requires a prior knowledge of the structure and hydraulic head distribution of the formation. The UVZ method is thus difficult to apply, or is inaccurate, in regions where little or no structural control exists or in areas that contain stratigraphic traps.

2) It does not account for capillary forces. In the original derivation (Hubbert, 1953) capillary forces were neglected based on the argument that in highly permeable rocks such as sandstones where any migration of consequence will occur, the capillary pressure contribution to the total formation pressure balance will be negligible. In stratigraphically trapped deposits, however, capillary forces have been shown to be important trapping factors (Berg, 1975; Davis, 1987; Jennings, 1987).

3) It is a tedious and often difficult task to calculate the U and V surfaces graphically by hand.

Despite these disadvantages the UVZ method has been widely applied (Hubbert, 1953; Dahlberg, 1982; Zawisa, 1986; Parks and Tóth, 1988).

2.3 Potentiometric Surface Analysis

Potential field theory has been applied in a different manner to fluid migration problems involving changes in lithology within the flow domain. Tóth (1962) and others (England et al, 1987; Obdam and Veling, 1987) observed that highly-permeable lenticular reservoirs situated in a uniform field of formation-fluid flow cause characteristic perturbations in that flow field. Tóth recognized this phenomenon (Tóth, 1962) and developed an oil exploration technique based on potentiometric surface analysis (Rakhit, 1987; Tóth and Rakhit, 1988)

This technique is based on the characteristic effect a highly permeable body has on a uniform field of formation-fluid flow. Figure 2.3 illustrates the effect of a lenticular rock body in such an environment. Fluid potential and flow lines are modified in and around the lens, focusing flow into the upstream, and out the downstream ends of the lens.

Previous work (Rakhit, 1987; Tóth and Rakhit, 1988) has focused on quantifying the characteristic effects of lenticular sand bodies on fluid-flow fields. The results showed that potentiometric patterns depend on the: regional fluid-potential gradient; matrix-to-lens permeability contrast; lens geometry; and orientation relative to the regional fluid-flow direction.

A trend surface/residual technique was developed to quantify these properties. First, a regional water potentiometric surface is constructed. The resulting surface displays localized anomalous areas if highly-permeable rock bodies are present. Next, the undisturbed, regional potentiometric surface is subtracted from the anomalous surface. The remaining surface (termed the potentiometric anomaly surface) is then contoured. Any anomalies are then characterized by comparison to theoretically derived anomalies to determine the size, shape, orientation, and

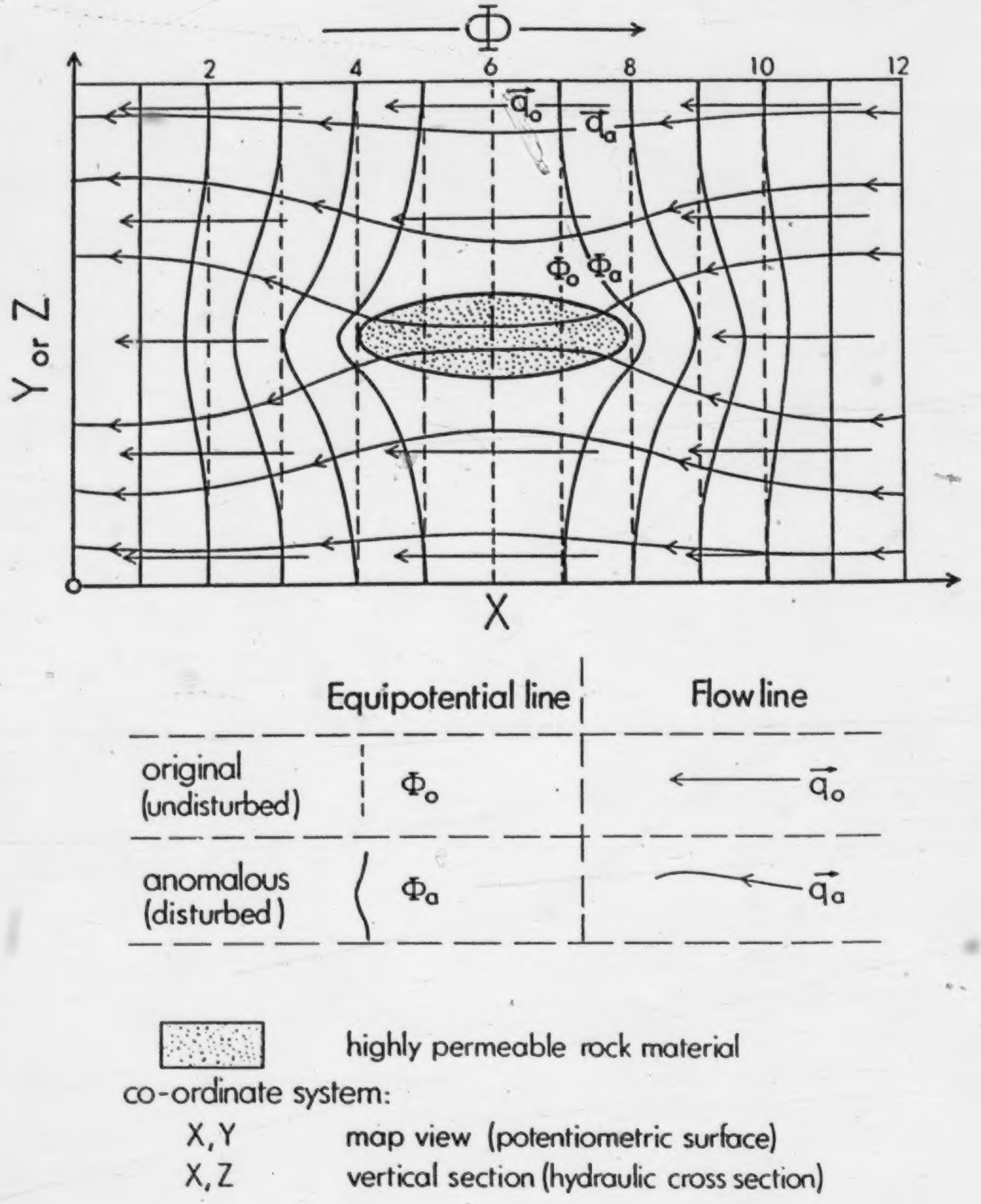

Φ
2
4
6
8
10
12
$\vec{q}_o$
$\vec{q}_a$
Φ_o Φ_a
Y or Z
X
Equipotential line
Flow line
original (undisturbed)
Φ_o
$\vec{q}_o$
anomalous (disturbed)
Φ_a
$\vec{q}_a$
highly permeable rock material
co-ordinate system:
X, Y map view (potentiometric surface)
X, Z vertical section (hydraulic cross section)

Figure 2.3: Effect of a highly-permeable body situated in a uniform field of formation-fluid flow (modified from Tóth and Rakhit, 1988).

quality of the potential reservoir bodies. Figure 2.4 illustrates a typical, but theoretically calculated potentiometric surface (2.4a) and the associated potentiometric anomaly surface (2.4b).

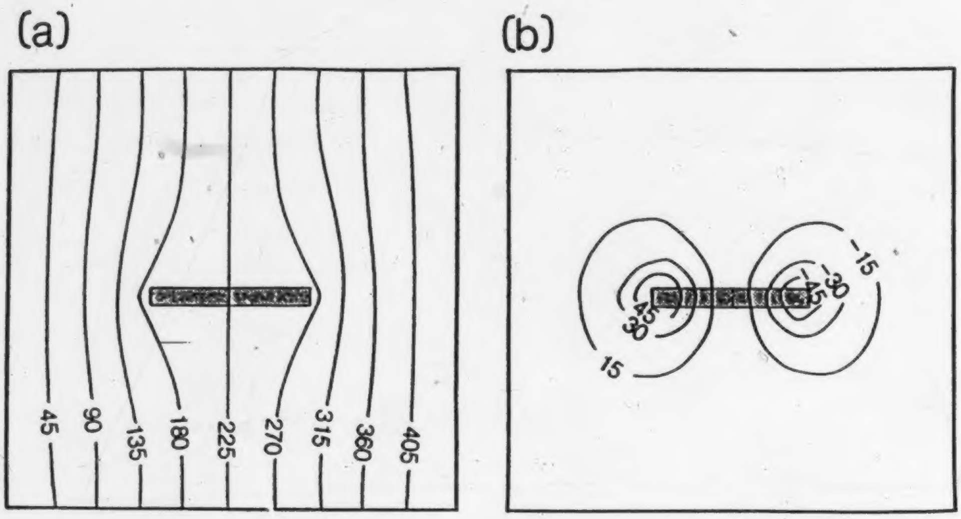
This method only considers single-phase (water) flow. Thus, reservoir-quality rock bodies, not oil filled reservoirs are located.

Tóth (1970) presents three arguments in support of this method, namely: 1) highly-permeable lenticular bodies act to "draw-in" any nearby migrating fluids (water and/or oil) from the surrounding low permeability framework; 2) capillary pressure relationships favor the passage of hydrocarbons from the lower permeability matrix into the reservoir, but act against movement in the opposite direction; and 3) simple mechanical filtration acts to retain any hydrocarbons already entered. Rakhit (1987) made use of these arguments to justify the use of the single phase technique for oil exploration.

The potentiometric surface analysis method does not account for the presence of oil, nor capillary forces in the flow domain.

2.4 Discussion

The preceding section outlined two oil exploration techniques based on the application of potential field theory to subsurface environments. Although similar in basis and objectives, each technique makes simplifying assumptions and therefore has limitations for practical applications.


(a)
(b)
45
90
135
180
225
270
315
360
405
15
30
45
-15
-30
-45

Potentiometric Surface

Potentiometric Anomaly Surface

L/W = 10:1

ε = 100

Figure 2.4: (a) Theoretically calculated potentiometric surface, and
(b) Associated potentiometric anomaly surface, for a lens with permeability contrast $\varepsilon = 100$, regional hydraulic gradient 0.02, lens size ratio 10:1. Contour values are in arbitrary units (modified from Tóth and Rakhit, 1988).

Neither technique gives any direct indication of the presence of hydrocarbons in the trap. Furthermore, neither technique accounts for the presence of capillary forces between the fluids.

The present study, on the other hand, investigates the effect of changing oil saturation, and the inclusion of capillary pressures on the fluid-potential fields, in an attempt to improve upon the UVZ, and potentiometric surface anomaly methods.

3.0 NUMERICAL SIMULATION OF OIL MIGRATION

Conventional hydrocarbon migration theories must be examined prior to the selection of a suitable numerical model for migration simulation.

3.1 Hydrocarbon Migration Theories

One of the most controversial topics found in the petroleum geology literature has been, and still is, hydrocarbon migration in the subsurface. Two assumptions regarding this process are widely accepted: first, that most hydrocarbons are sourced from shale (low permeability) "source rocks" (Tissot and Welte, 1984); and second, that much of the hydrocarbons found to date are not situated in these same "source rocks". Therefore, some sort of migration must have occurred.

As is commonly done, the migration process is considered for this study to take place in two stages: primary and secondary migration. Primary migration is defined as:

> movement of the newly generated petroleum from the low permeability source rock to its first encounter with higher permeability beds... the (migration) distance involved is typically in the range (of) up to one kilometre (England et al, 1987, p.332)

Secondary migration is defined as the movement of petroleum from the point of cessation of primary migration, through a higher permeability carrier bed, to a location where trapping and concentration may occur (Figure 3.1). Typically, secondary migration occurs on a larger scale than

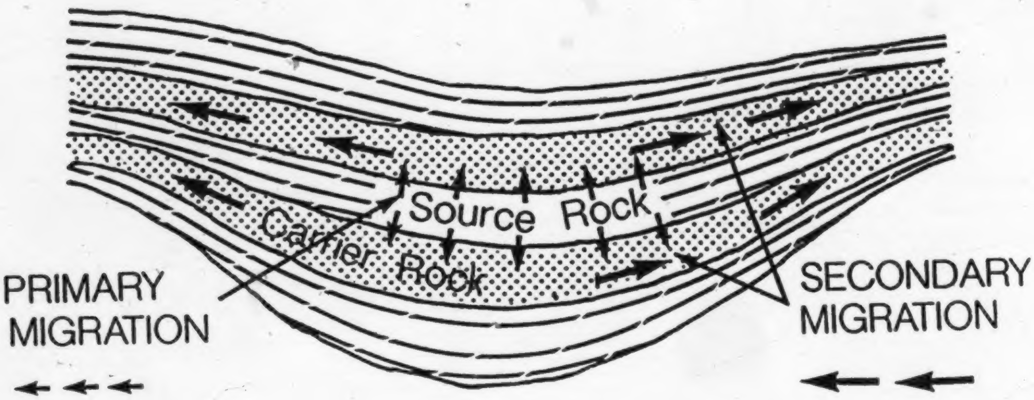

Source Rock
Carrier Rock
PRIMARY MIGRATION
SECONDARY MIGRATION

Figure 3.1: Schematic diagram illustrating primary and secondary hydrocarbon migration (modified from Tissot and Welte, 1984).

does primary migration; distances of over 100 kilometres are known to exist (Creaney and Allan, 1988).

Detailed reviews of the proposed modes and mechanisms of primary migration can be found in the literature (McAuliffe, 1980; Tissot and Welte, 1984; North, 1985). The arguments are unresolved, and it is not the intent of this work to resolve them. Instead, it is assumed that primary migration (by whatever means) has already occurred, creating a supply of hydrocarbons which are available for secondary migration. Simulations to be presented later deal with secondary migration only.

A literature review suggests two viable forms of secondary migration, namely: aqueous solution or separate phase.

Aqueous solution migration theories (e.g., Price, 1976) are not popular in the literature. Opponents of dissolved migration theories invoke low hydrocarbon solubilities and geochemical dissimilarities between source and resulting oil (McAuliffe, 1980) to refute this mechanism. Nevertheless, long distance secondary migration in solution cannot be eliminated as a mechanism, because all combinations of solubility enhancement agents have not been investigated.

Secondary migration as a separate phase is by far the most popular transport mechanism (Schowalter, 1979; England et al, 1987), with others considering it to be the definitive mechanism (Tissot, 1987). Arguments against the separate phase theory focus on the irreducible oil saturation concept, which is the immobile portion of the oil that must be in place before migration can proceed past that point. This petroleum, once emplaced in the pore-space along a migration path, is "locked up" from further migration. This results in an inefficient migration process (Mackenzie and Quigley, 1988) which would leave a residual oil "trail" between the source and trap. These "trails" are not commonly encountered.

Despite these shortcomings, separate-phase hydrocarbon movement in water-saturated carrier beds is the most popular mechanism. Numerical simulations conducted in this study treat secondary migration as a separate-phase transport problem through a water-wet carrier bed, similar to that discussed in Schowalter (1979) and England et al (1987). Factors influencing fluid migration directions and rates are: water flow direction and rate (controlled by the water potentiometric surface); oil flow directions (controlled by buoyancy forces due to density differences); and capillary forces between the phases. Any analysis of secondary migration must account for these variables.

3.2 Flow Models

A large number, and wide variety of flow models have been produced that deal with fluids migrating in the subsurface. Models dealing with aspects of migration that are wholly, or in part, applicable to this work can be broken down into six groups: (1) conceptual/numerical basin-scale fluid-flow models; (2) single-phase groundwater flow models;

(3) multiple-phase groundwater flow models; (4) hydrocarbon exploration models; (5) regional hydrocarbon migration models; and (6) multiple-phase reservoir production simulators.

Conceptual basin-scale flow models can be found in the literature, dating back over 50 years. These deal with theories of regional fluid migration in immature and mature basins of various geometries, with fluid flow driven by various mechanisms. They do not consider small scale migration and entrapment processes. An excellent review of these models can be found in Tóth (1986).

Numerical groundwater flow-models have become a fundamental tool for analyzing fluid flow in the subsurface. Single phase models have been developed using a wide variety of techniques (e.g., finite difference and finite element formulations). These models have been used to solve a large number of flow-related problems. Huyakorn and Pinder (1983) provide an in-depth history and description of most major numerical groundwater flow-models.

Groundwater flow models have only recently begun to deal with multiphase flow, those being applied to the study of Non-Aqueous Phase Liquid (NAPL) contamination problems. Notable two phase models include the models developed by Little (1983), Abriola and Pinder (1985 a,b), Faust (1985), Faust and Rumbaugh, (1986), and Osborne and Sykes (1986). An excellent overview of these models is presented in Pinder and Abriola (1986).

Numerical hydrocarbon-exploration models are a more recent development, with the advent of high-capacity, high-speed computers. Early works (Welte and Yükler, 1981) led to the development of more sophisticated models, including those of Durand et al (1983), Ungerer et al (1984; 1987), Nakayama (1987), Nakayama and Lerche (1987a,b), and Jabour and Nakayama (1988). In general, these models consider basin subsidence, compaction, source rock maturation, primary migration and expulsion, and secondary migration and entrapment. They are usually multiphase, multi-dimensional, compaction-driven flow models, where hydrocarbons are driven by over-pressures generated during compaction, and buoyancy forces acting on the oil. They do not consider gravity-driven groundwater flow as a transport mechanism, nor do they consider local scale entrapment processes.

Garven (1989) presents a regional, gravity-driven migration model which portrays the formation of the giant Athabasca oil sands deposits. His model (actually 2 separate models) considers basin-scale secondary hydrocarbon migration via both dissolved-phase and separate-phase modes. This work provides an interesting comparison between separate-phase and soluble-phase migration times and efficiency. In the formulation, however, capillary pressures are not included.

Many examples of standard reservoir simulators are available (e.g., Franchi et al 1982). These simulators account for multiple phases, multiple dimensions, and capillary pressures, but are designed for hydrocarbon production-performance modelling. As such, they have not been widely applied to the study of petroleum migration and entrapment.

In summary, each model was developed for a particular problem and each has its own advantages and disadvantages. Conceptual basin-scale models do not produce fluid-potential distributions. Groundwater flow models do not consider multiphase flow. Hydrocarbon expulsion models do not consider gravity driven flow. Garven's regional migration model does not consider capillary pressures. Finally, reservoir simulators are not commonly applied to basin-scale flow problems. This leaves the multiphase groundwater flow models.

After a careful review of the existing and available models, SWANFLOW-2D: Simultaneous Water, Air and Nonaqueous Phase Flow Model in Two Dimensions (Faust and Rumbaugh, 1986) was selected. It is a multiphase groundwater flow model and was obtained (free of charge) from the authors, specifically for this study.

3.3 SWANFLOW-2D

In this section a brief review of the formulation, solution technique, assumptions, limitations, and computer implementation of the model will be given. A more detailed description can be found in Faust (1985) or Faust and Rumbaugh (1986).

The equations describing isothermal, immiscible, multiphase fluid flow in a porous medium can be written (Peaceman, 1977) as:

$$\nabla\left[\frac{k\,k_{rw}\,\rho_w}{\mu_w}\left(\nabla p_w - \rho_w\, g\, \nabla d\right)\right] + q_w^* = \frac{\partial(\phi\, \rho_w\, s_w)}{\partial t} \qquad (3.1)$$

$$\nabla\left[\frac{k\,k_{ro}\,\rho_o}{\mu_o}\left(\nabla p_o - \rho_o\, g\, \nabla d\right)\right] + q_o^* = \frac{\partial(\phi\, \rho_o\, s_o)}{\partial t} \qquad (3.2)$$

$$\nabla\left[\frac{k\,k_{rg}\,\rho_g}{\mu_g}\left(\nabla p_g - \rho_g\, g\, \nabla d\right)\right] + q_g^* = \frac{\partial(\phi\, \rho_g\, s_g)}{\partial t} \qquad (3.3)$$

where: ∇ : the differential operator; t : time [T]; d : depth with respect to a common datum [L]; ϕ : porosity; q^* : source/sink rate [L^3/T]; ρ : fluid density [M/L^3]; μ : fluid dynamic viscosity [M/LT]; p : fluid pressure [M/LT^2]; s : fluid saturation; k_r : relative permeability. (the subscripts refer to a particular fluid)

In a pore space saturated with three fluids the following relation is also true:

$$s_w + s_o + s_g = 1 \qquad (3.4)$$

From these general equations, three simplifying assumptions are made: (1) the gas phase is immobile, and pressure gradients in it are negligible; (2) fluid viscosity is not a function of pressure; and (3) fluid density is not a function of pressure.

Using these assumptions, equations 3.1, 3.2, and 3.3 can be combined with equation 3.4, and equation 2.7 (written for oil/water and oil/gas conditions), to yield equations 3.5 and 3.6, which are the final forms of the differential equations:

$$\nabla\left[\frac{k\,k_{rw}\,\rho_w}{\mu_w}\left(\nabla p_o - \rho_w g \nabla d\right)\right] + q_w^* = \frac{\partial\left(\phi\,\rho_w\,s_w\right)}{\partial t} + \nabla\left[\frac{k\,k_{rw}\,\rho_w}{\mu_w}\,\nabla p_{cow}\right] \quad (3.5)$$

$$\nabla\left[\frac{k\,k_{ro}\,\rho_o}{\mu_o}\left(\nabla p_o - \rho_o g \nabla d\right)\right] + q_o^* = \frac{\partial\left(\phi\,\rho_o\left(1 - s_w - s_g\right)\right)}{\partial t} \quad (3.6)$$

In these two equations there are seven unknowns: oil pressure (p_o); water saturation (s_w); relative permeability to oil (k_{ro}); relative permeability to water (k_{rw}); oil-water capillary pressure (p_{cow}); oil-gas capillary pressure (p_{cog}), which is included in the oil pressure term; and gas saturation (s_g).

For the two phase (oil/water) flow problem, gas saturation (s_g) is set equal to zero. Any of the functional relationships pertaining to gas are not required.

The formulation is completed with the specification of four independent relationships: relative permeability to water ($k_{rw}(s)$); relative permeability to oil ($k_{ro}(s)$); oil-water capillary pressure ($p_{cow}(s)$); and porosity as a function of pressure ($\phi(p)$).

Porosity is related to fluid pressure through the rock compressibility equation (equation 3.7), which is written as:

$$\phi = \phi_r\left[1 + c_f\left(p - p_r\right)\right] \quad (3.7)$$

where: c_f : formation compressibility [LT^2/M]; p_r : reference pressure [M/LT^2]; ϕ_r : porosity at the reference pressure; and p : fluid pressure (water) [M/LT^2].

Relative permeability to oil, and to water, and capillary pressure relationships are obtained from standard laboratory tests on rock samples, which will be discussed in section 4.3.

With these four relationships specified, the formulation of the problem is complete, leaving two equations (3.5 and 3.6) in two unknowns (oil pressure and water saturation). The numerical model must solve these equations at each timestep.

In SWANFLOW-2D, a block centred, fully implicit, finite-difference solution scheme is used. Equations 3.5 and 3.6 are written in difference form for each grid block in the flow domain. This leads to a system of non-linear differential equations. This system of equations contains non-linearities that can cause severe numerical instabilities during solution. The solution is linearized using a Newton-Raphson iteration procedure, before the coefficient matrix is formulated. Once formulated, the matrix is banded, but not symmetric, and is solved directly using a Gauss-Doolittle algorithm.

With the derivation in this model, three critical assumptions have been made, namely: an immobile gas phase; a constant fluid viscosity; and a constant fluid density. These have a bearing on both the problems that can be solved, and the accuracy of the results that can be expected.

The immobile gas phase assumption is of no concern due to the two phase nature of the problem considered.

The second and third assumptions are much more critical. By assigning constant values to fluid viscosities and densities, the solution scheme is made faster, and more stable. However, this affects the applicability of the model, and possibly the accuracy of the results. In the user's manual, the authors state explicitly "the model cannot treat highly pressurized systems, e.g. petroleum reservoirs,... confined conditions can be simulated however" (Faust and Rumbaugh, 1986, p. 10).

In this study, the "reservoir" does not undergo major pressure changes, as would be experienced under production depletion. In fact, the magnitude of the pressure drop across a typical grid was quite small. Discussion of the effect of these assumptions on the results of the simulations will be presented in section 7.0. Any errors as a result of the constant viscosity and density assumptions are small in comparison to the actual results, therefore these errors can be neglected.

Once the model was selected, it was implemented and tested on various computers (IBM/XT, Amdahl 5870, Cyber 205). The simulations presented in sections 5.0 and 6.0 were run on The University of Calgary's CYBER 205 supercomputer.

4.0 INPUT PARAMETERS

This study was conducted in conjunction with a field-data based petroleum-hydrogeological study (Parks, 1989) of the Belly River Formation in an area in west-central Alberta. Input data were obtained from a wide variety of sources, with a common goal: to set up a hypothetical, but realistic, model of secondary migration and subsequent entrapment of oil in a Belly River sandstone reservoir.

Model input data fall into four groups: flow-domain geometry and discretization data; physical properties of the rock and fluid; initial conditions and injection data; and the numerical-model control parameters.

An overview of the geology of the Belly River Formation will be presented first, to provide a setting for the simulations. Then, each of the four data groups will be presented, the selection justified, and related to the common Belly River theme.

4.1 Setting of Representative Area

4.1.1 Location

Data used in this study were taken from a 10 by 10 township region, southwest of Edmonton, in west-central Alberta (Figure 4.1). This region is bounded by the Fifth Meridian to the east, Range 10 to the west, Township 40 on the south, and Township 49 on the north. There are two

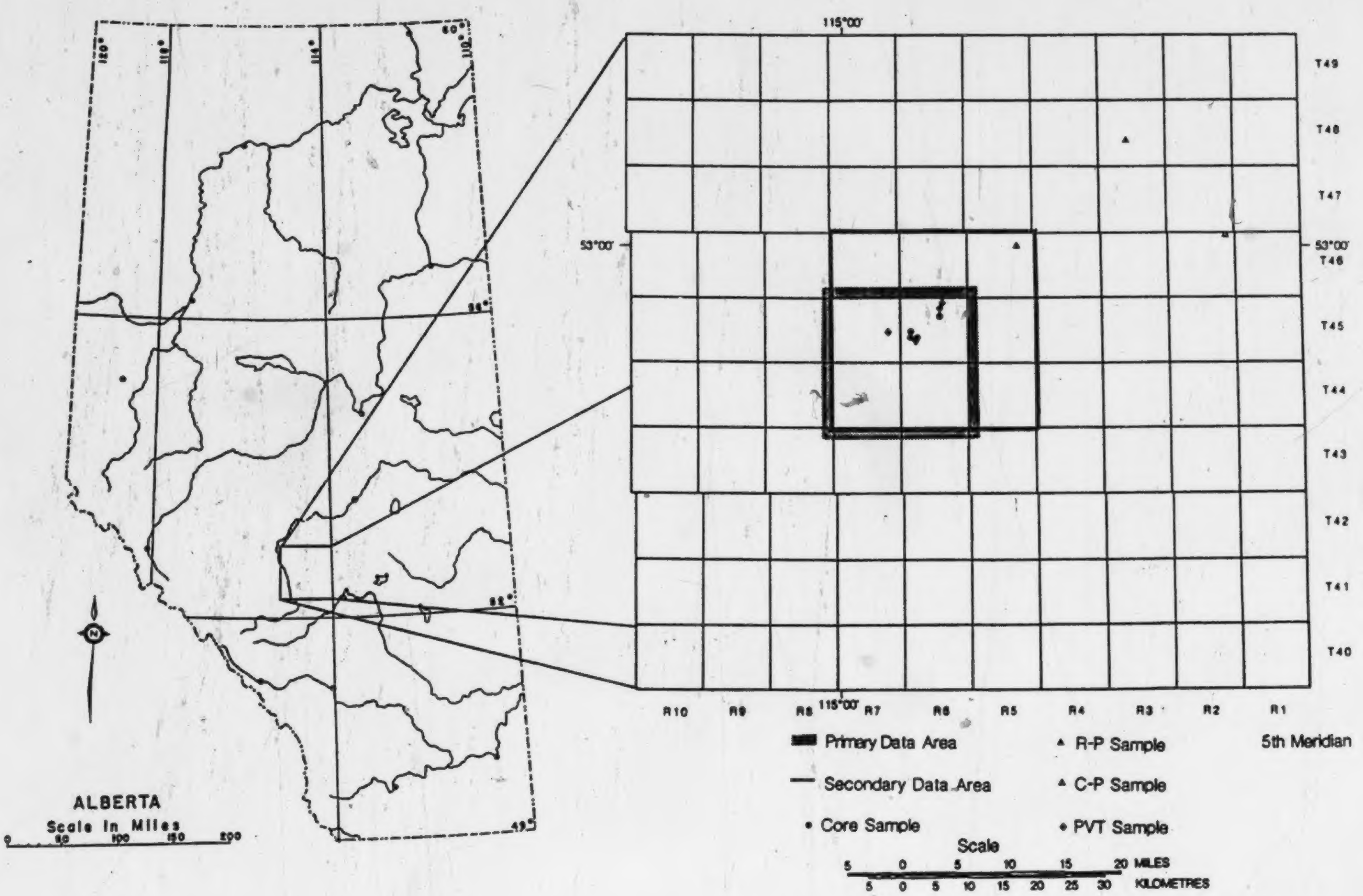

ALBERTA
Scale In Miles
0 50 100 150 200
120°
118°
114°
110°
60°
55°
52°
49°
115°00'
53°00'
T49
T48
T47
T46
T45
T44
T43
T42
T41
T40
R10
R9
R8
R7
R6
R5
R4
R3
R2
R1
5th Meridian
Primary Data Area
Secondary Data Area
Core Sample
R-P Sample
C-P Sample
PVT Sample
Scale
5 0 5 10 15 20 MILES
5 0 5 10 15 20 25 30 KILOMETRES

Figure 4.1: Location of representative area.

smaller sub-areas within this large area, namely, the primary and secondary areas.

The primary data area is a four township parcel on which a detailed petroleum hydrogeological study was conducted by a co-worker (Parks, 1989).

Any further data that could not be obtained from the primary data area were obtained from the secondary area (if possible) or finally, from within the representative area. The locations of all data used for the simulations are illustrated in Figure 4.1.

4.1.2 Geology of the Belly River Formation

Regionally, the Belly River Formation is a wedge-shaped package of continental clastic sediments deposited as a result of the eastward withdrawal of the Lea Park Sea during Campanian time in the Late Cretaceous Period (Iwuagwu and Lerbekmo, 1984; Podruski et al, 1988). Within the study area, the unit is bounded below by the marine Lea Park shale, and above by the marine Bearpaw shale (Figure 4.2). This section is approximately 300 metres thick (Table 4.1), and consists of interbedded conglomerates, sandstones, siltstones, and shales.

Several authors (Ogunyomi and Hills, 1977; Iwuagwu and Lerbekmo, 1984; Podruski et al, 1988; Sabry, 1988) have proposed a variety of depositional environments for the Belly River Formation, including almost all possible clastic

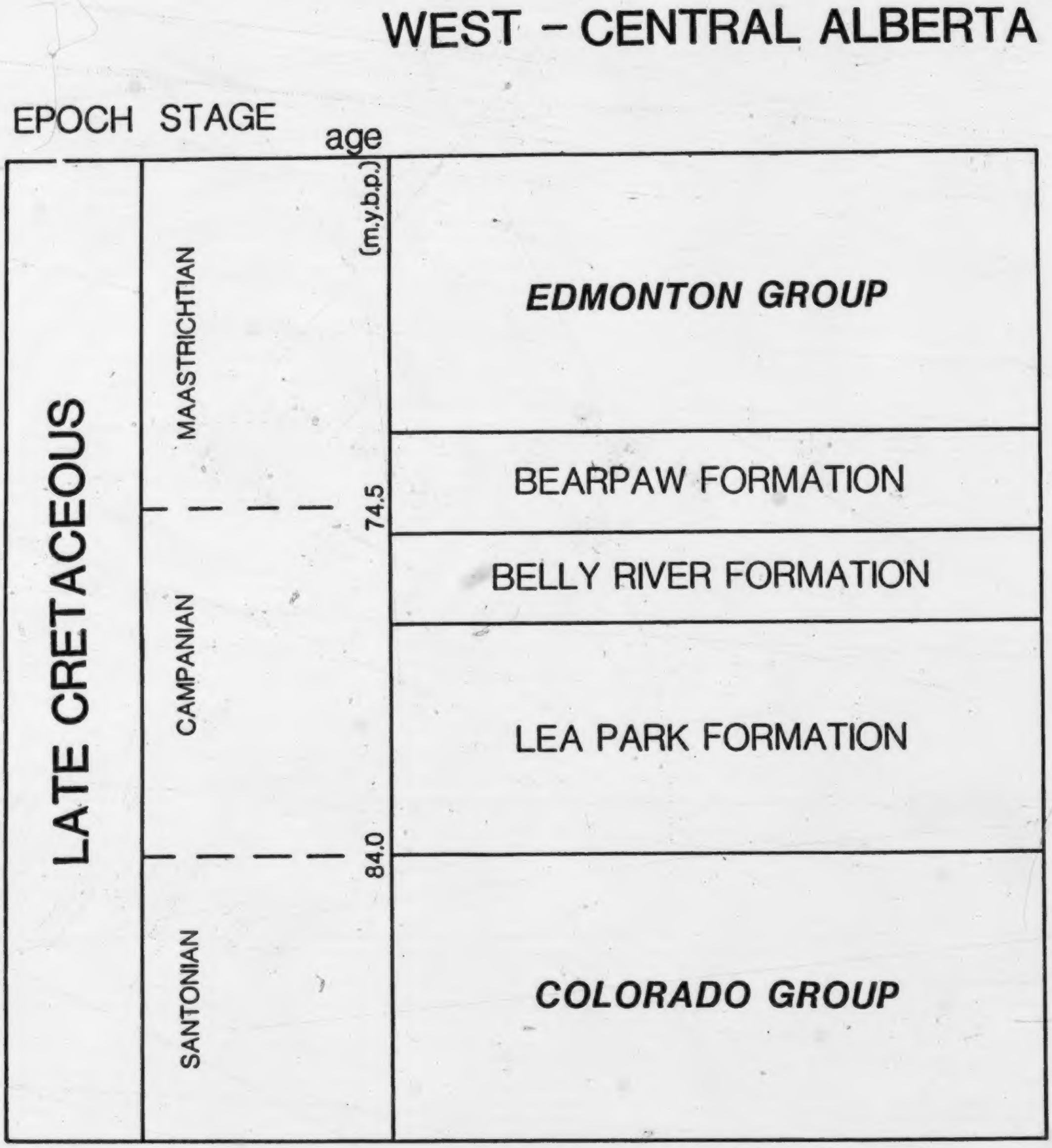

WEST - CENTRAL ALBERTA
EPOCH
STAGE
age
(m.y.b.p.)
LATE CRETACEOUS
MAASTRICHTIAN
CAMPANIAN
SANTONIAN
74.5
84.0
EDMONTON GROUP
BEARPAW FORMATION
BELLY RIVER FORMATION
LEA PARK FORMATION
COLORADO GROUP

Figure 4.2: Table of formations - study area (modified from Podruski et al, 1988 and AGAT Laboratories).

Table 4.1

Thickness of gross Belly River section in selected wells.

Well	Gross Belly River Interval (metres)	Source
06-01-44-6 W5	278.3	(1)
16-20-44-6 W5	255	(1)
15-35-44-6 W5	290.8	(1)
09-14-44-6 W5	279.8	(1)
07-33-44-7 W5	281.0	(1)
04-01-45-6 W5	303.5	(1)
14-21-45-6 W5	231	(1)
06-33-45-6 W5	269	(1)
06-12-45-6 W5	395	(1)
08-16-45-7 W5	294.4	(1)
12-29-45-7 W5	299.3	(1)
06-18-47-6 W5	350.5	(2)
11-03-42-2 W5	335.3	(2)
Average	297.1 metres	

source : (1) Petroleum Information Exchange (PIX) Cards
(2) Williams and Burk, 1964

environments. Most commonly a deltaic or related environment is suggested.

The formation is informally divided into two sections based on depositional environments and an exploration/ functional scale (Shouldice, 1979): the Basal Belly River Sand, and the Upper Belly River Sands. The Basal Belly River Sand is defined as the first sand that conformably overlies the Lea Park Shale. It is generally thought to be of marine origin, and is found as an eight to ten metre thick "sheet" sand, which exists over the entire study area, and most of the depositional area of the formation. The Upper Sands are generally thought to be fluvial in origin. They are mostly discontinuous, interbedded, lenticular reservoirs, 1.5 to 30 metres (5 to 100 feet) thick (Lerbekmo, 1963)

Shouldice (1979) identified three major hydrocarbon trapping styles in the Belly River Formation. Two of these, updip sand pinchouts into marine shales, and gentle structures involving widespread sands, are associated with traps and oil reservoirs found in the Basal Sand. In the Upper Sands, Shouldice identified the trapping mechanism as "stratigraphic traps".

4.2 Grid Geometry

A block-centred, finite-difference grid was constructed (Figure 4.3). This grid represents a slice through the Belly River Formation which is 1250 metres in length, 300 metres thick (top to bottom), and 1 metre thick in the third

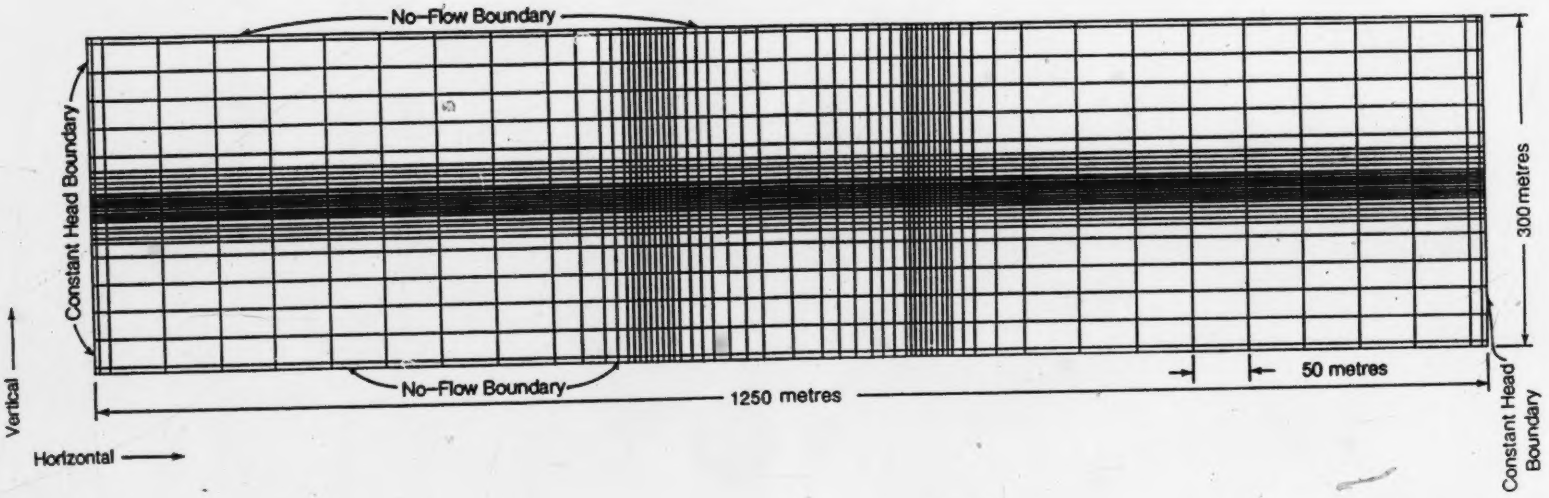

No–Flow Boundary
Constant Head Boundary
300 metres
50 metres
No–Flow Boundary
1250 metres
Constant Head Boundary
Vertical
Horizontal

Figure 4.3: 1800 block, finite-difference grid used to accommodate a 250 by 25 metre, elliptical, Belly River Formation reservoir.

direction. The flow domain is discretized using 60 blocks in the horizontal and 30 blocks in the vertical directions. Block thicknesses in the horizontal direction vary from 5 to 50 metres and vertical thicknesses vary from 2.5 to 25 metres. This variable spacing was selected to (1) accommodate the boundaries of the lens situated within the flow domain, and (2) to provide sufficient detail (via close grid spacing) in areas of expected high fluid-potential gradients. Closely-spaced grid blocks were specified at the grid boundaries to control the boundary conditions and to improve the accuracy of output plotting and contouring.

The grid was constructed to accommodate a single, 250 metre long (horizontal) by 25 metre (vertical), elliptical reservoir. This was considered to be a typical reservoir found in the Upper Belly River system. The ellipse, located at the centre of the flow domain, has an aspect ratio (L/W) of 10:1. It was situated far away from the grid boundaries to avoid any boundary interference.

To accommodate the curved lens boundary with a block-shaped discretization, the boundary must be approximated using a "stepped" edge. Ideally, to improve accuracy and resolution, the steps should be small in relation to the size of the lens. The number of steps, however, is limited by available computer memory. A compromise was reached between lens shape, and number of grid blocks used for discretization. A detail of the lens discretization is shown (Figure 4.4).

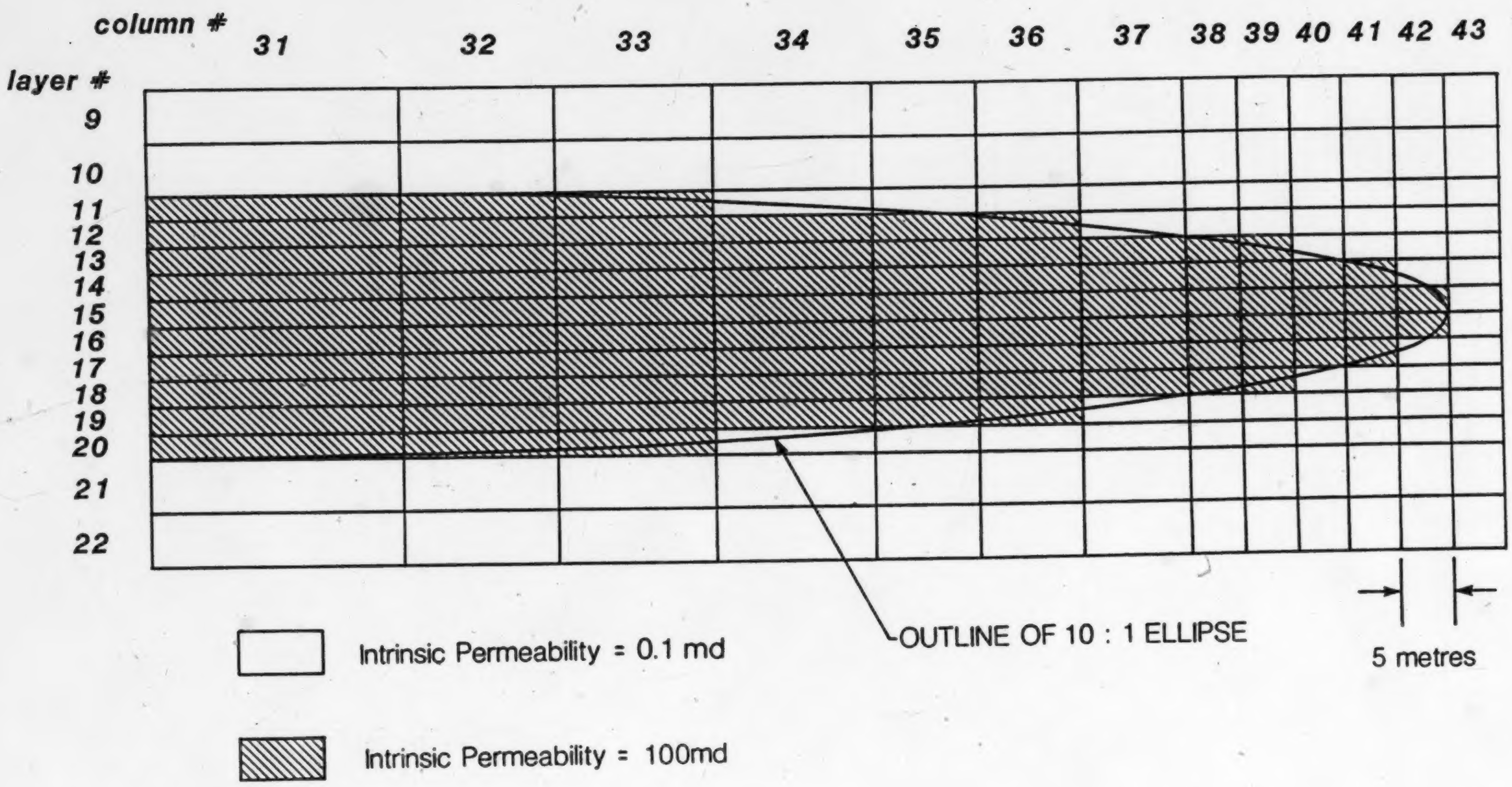

column #
31
32
33
34
35
36
37
38
39
40
41
42
43
layer #
9
10
11
12
13
14
15
16
17
18
19
20
21
22
OUTLINE OF 10 : 1 ELLIPSE
5 metres
Intrinsic Permeability = 0.1 md
Intrinsic Permeability = 100md

Figure 4.4: Detail of a portion of the lens discretization.

The grid was set up with no-flow boundaries on the top and bottom, to confine flow to the horizontal domain. Fixed head boundaries were set up at both ends of the grid, to control the regional fluid-potential gradient across the grid.

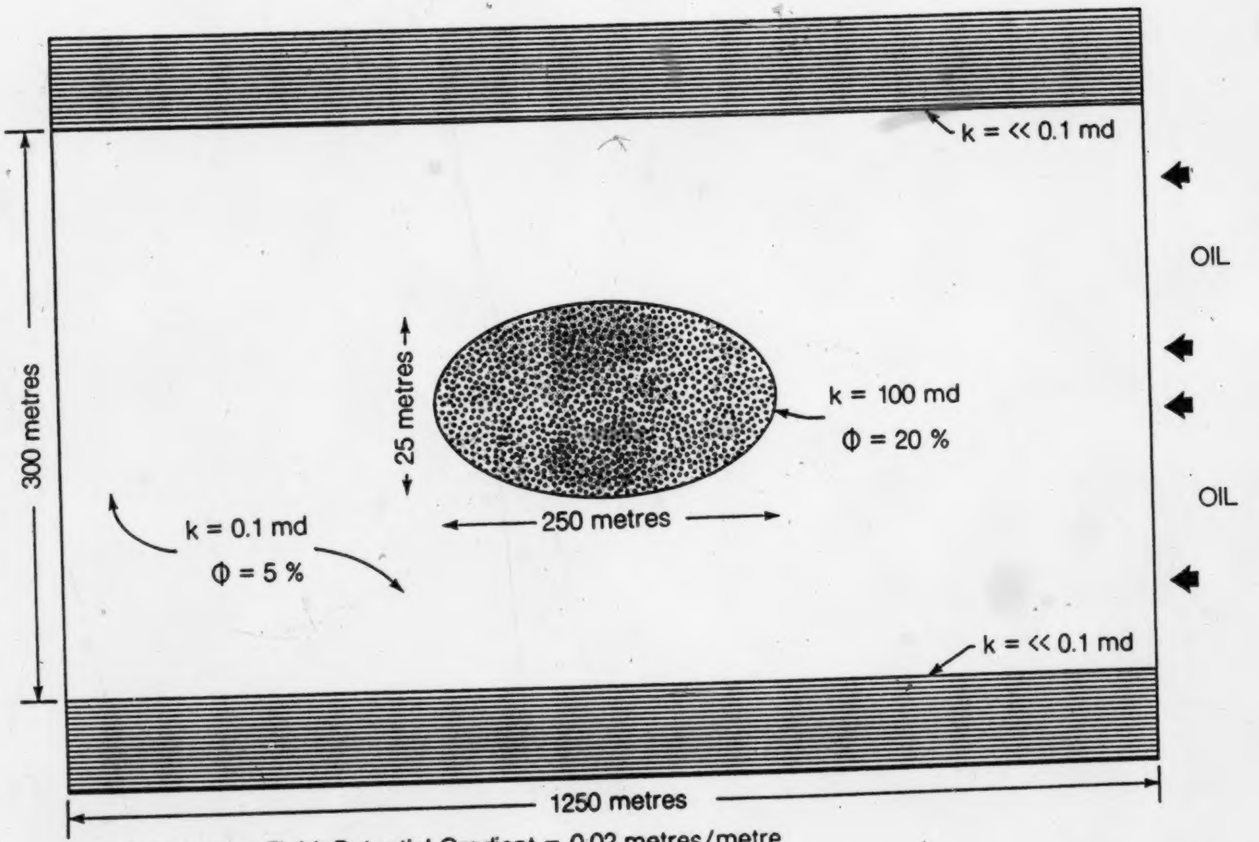
As constructed, the grid simulates a single lenticular reservoir, representative of those found in the Upper Belly River Formation, situated within a 300 metre thick flow domain (Figure 4.5). Flow is confined to the interval in the model by the upper and lower no-flow boundaries. This simulates confinement of flow in the Belly River Formation by the Bearpaw and Lea Park shales, on the top and bottom of the formation respectively.

4.3 Physical Properties

Table 4.2 provides a summary of all parameters used in the simulations, described in further detail below.

4.3.1 Permeability and Porosity data

Permeability data are of two types: intrinsic (porous medium) permeability; and relative (rock-fluid) permeability. Intrinsic permeability is a function of the rock only. Relative permeability is a function of the rock, and of the degree of saturation and physical properties of the particular fluid in the rock. Both types of permeability data were obtained from the Alberta Energy Resources Conservation Board (AERCB) files.


k = << 0.1 md
OIL
k = 100 md
Φ = 20 %
25 metres
300 metres
250 metres
k = 0.1 md
Φ = 5 %
OIL
k = << 0.1 md
1250 metres

Regional Water Fluid–Potential Gradient = 0.02 metres/metre

Permeability Contrast $\varepsilon = 1000$

Lens L/W = 10 : 1

(not to scale)

Figure 4.5: Schematic cross-section of the flow domain.

Table 4.2

Simulation Data

Discretization Data

Number of grid blocks in X direction: 60
X direction (horizontal) length : 1250 metres
Number of grid blocks in Y direction: 30
Y direction (vertical) length : 300 metres
Lens: 10:1 ellipse
250 metres (horizontal) by
25 metres (vertical)

Fluid Data

Oil viscosity : 2.0 mPa·s
Water viscosity : 1.0 mPa·s
Water density : 1000 kg/m^3
Oil density (Case One) : 1000 kg/m^3
(Case Two) : 850 kg/m^3

Simulation Parameters

Mass balance tolerance : .01 percent
Maximum number of iterations/step : 5
Timestep length : 500 years

Porous Medium Data

Permeability, "matrix" : 0.1 md
Permeability, "reservoir : 100.0 md
Permeability contrast : 1000
Homogeneous, and isotropic.
Porosity, "matrix" : 5 percent
Porosity, "reservoir" : 20 percent
Compressibility : $1.0 \cdot 10^{-10}$ (kPa^{-1})

Fluid Injection Data

Total injection rate : $1.89 \cdot 10^{-2}$ m^3/yr
Fluid composition : 90 % water / 10 % oil

Fluid-Potential Data

Regional gradient : 0.02 metres/metre
Hydraulic head (upstream) : 625 metres
(downstream) : 600 metres

Four wells in the primary data area contained analyzed core samples from within the upper portion of the formation (6-27-45-6, 8-18-45-6, 16-18-45-6, and 6-17-45-6, W5M). Intrinsic permeabilities obtained from these samples ranged from less than 0.1 millidarcys (md) to greater than 10,000 millidarcys (md).

To be able to relate calculated and theoretically derived anomalies, a lens/matrix permeability ratio of 1000 was used. This was selected to generate as large an anomaly as possible, to test if it would be visible.

With this in mind, the low permeability unit was assigned an intrinsic permeability of .1 md ($1.0 \cdot 10^{-16}$ m^2), which is consistent with a low permeability sandstone or shale (Freeze and Cherry, 1979). The reservoir sandstone was assigned a value of 100 md ($1.0 \cdot 10^{-13}$ m^2), which is consistent with the typical range of permeabilities found in Belly River oil pools in the study area (Iwuagwu and Lerbekmo, 1982).

Relative permeability data were obtained from special core analysis studies completed for secondary recovery work. These special core analysis studies were conducted on nine different wells within the data area, yielding 27 oil-water relative permeability curves. The selection of a typical curve for the simulations was made arbitrarily, based on the relative permeability curve that exhibited the most representative irreducible water (S_{wi}) and oil (S_{oi})

saturations, combined with an intrinsic permeability as close as possible to 100 md.

Appendix 1 summarizes results of the waterflood tests conducted on core samples within the representative data area.

It can be seen that S_{wi} averages approximately 46 percent within a range of 25 to 65 percent. These high connate water saturations are typical of most Belly River reservoirs, and are indicative of strongly water-wet conditions (Hunter, 1966). Average S_{oi} is approximately 25 percent, ranging between 15 and 42 percent. Porosities average about 17 percent, within a range of 13 to 22 percent. Effective intrinsic permeabilities range from 0.14 to 379 md for the reservoir portions of the samples.

The relative permeability curve from 6-16-48-3 W5 obtained from a sample taken at approximately 952.01 metres (average of 3122.9 - 3123.9 feet) depth from Kelly Bushing (KB) was selected as most representative of the Belly River Formation in the study area (Figure 4.6). It can be seen that the S_{wi} (45.8 percent) and S_{oi} (21.8 percent) closely match the average figures (Appendix 1). The sample intrinsic permeability was 33 md, which was input as 100 md for ease in comparison, as stated earlier. Data point values were interpolated to even five percent values and rounded slightly (i.e. S_{wi}=45 percent, S_{oi}=20 percent) for clarity in model input.

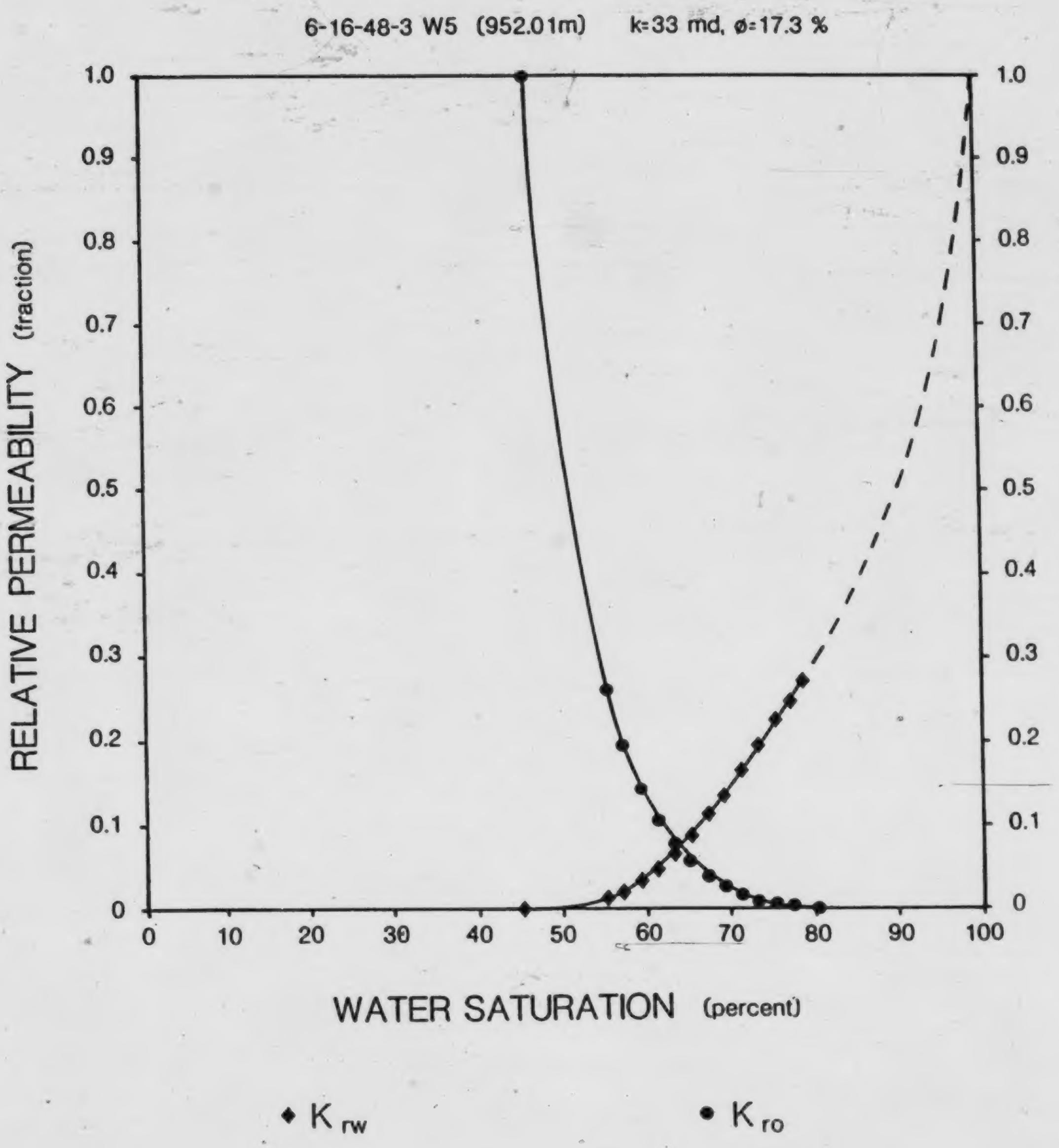


Figure 4.6: Oil/Water relative permeability curves (source: AERCB).

Porosities obtained from core analysis ranged from 0 to approximately 19 percent (AERCB). Values obtained from special core analysis ranged up to 22 percent (Appendix 1). Based on this, 20 and 5 percent porosities were selected for the high and low permeability units, respectively. These values are consistent with values found by Iwuagwu and Lerbekmo (1982) on a detailed study of a reservoir just north of the primary data area.

4.3.2 Capillary Pressure Data

Capillary pressure curves illustrate the empirically determined relationship between fluid saturation in the pore space and the pressure between the fluids in the pore space. They are a function of the rock and the fluids present, and are important factors influencing oil migration (Berg, 1975; Jennings, 1987). Capillary pressure curves are generated as part of a package of special core analysis studies and are of two distinct types: mercury and air-brine.

A mercury-injection capillary pressure test is performed on a cleaned, dried rock sample. Mercury is injected at various (increasing) pressure levels, and the mercury saturation in the sample is measured as a function of injection pressure. Each test, (generating one capillary pressure curve), requires a lengthy stabilization time at each pressure/saturation level. As such, they are time-consuming and expensive, and are not commonly performed.

The air-brine test procedure is similar to the mercury procedure. Fluid (usually formation brine) is injected into an evacuated (air saturated) sample, as with the mercury procedure. These are faster to perform, much more common, but do not represent the actual fluid-fluid conditions present in the pore-space. Air-brine curves are used (out of necessity) to describe oil/water or oil/gas conditions in the reservoir (Craig, 1971).

Within the representative data area, 12 wells have capillary pressure data, yielding seven mercury, and 65 air-brine curves. Unfortunately, only one mercury curve was available in the primary area.

A comparison between mercury and air-brine curves showed only minor differences between them at water saturations greater than S_{wi}. Below S_{wi}, the two types of curves differ. For mercury injection curves, higher final injection pressures are used, resulting in fluids being forced into the smallest pore-spaces in the sample. This results in lower final values of S_{wi} when using the mercury technique. In this study, S_{wi} was controlled by the relative permeability curves, thus air-brine curves were sufficient.

To simulate conditions in the study area, a capillary curve from a rock sample having 100 md permeability and 20 percent porosity was desired. The closest sample with these properties came from a depth of 1066.8 m (3500 ft) KB, from 10-12-47-4 W5, which had: 100 md permeability; 18 percent porosity; and an extrapolated entry pressure of 6.9 kPa (1 psi). This sample had a S_{wi} much less than 40 percent, which did not fit in with the relative permeability curves. Therefore, a curve that had (1) a 6.9 kPa entry pressure; (2) k = 100 md, (3) porosity = 20 percent, (4) S_{wi} near 45 percent, and (5) was within the primary data range, was sought. Unfortunately, none of the available curves fit these criteria.

The curves selected (Figure 4.7) were a compromise between these factors. For the high permeability unit, a curve from 14-26-46-5 W5 (1164.77 m KB) was selected. The low permeability unit curve was selected from 12-36-46-2 W5 (9844.84 m KB). These curves were interpolated to even five percent saturation values and input into the model.

4.3.3 Pressure-Volume-Temperature Data

Fluid properties are a function of temperature and pressure. To select fluid viscosities and densities properly, approximate formation pressures and temperatures were required.

In the primary data area, the top of the Belly River Formation is located approximately 1000 to 1400 metres below land surface, placing the centre of the formation at approximately 1200 metres depth below land surface (K. Parks, 1989, personal communication). Bottom hole temperatures obtained from wells yield formation temperatures in the range of 50 to 60 °C.

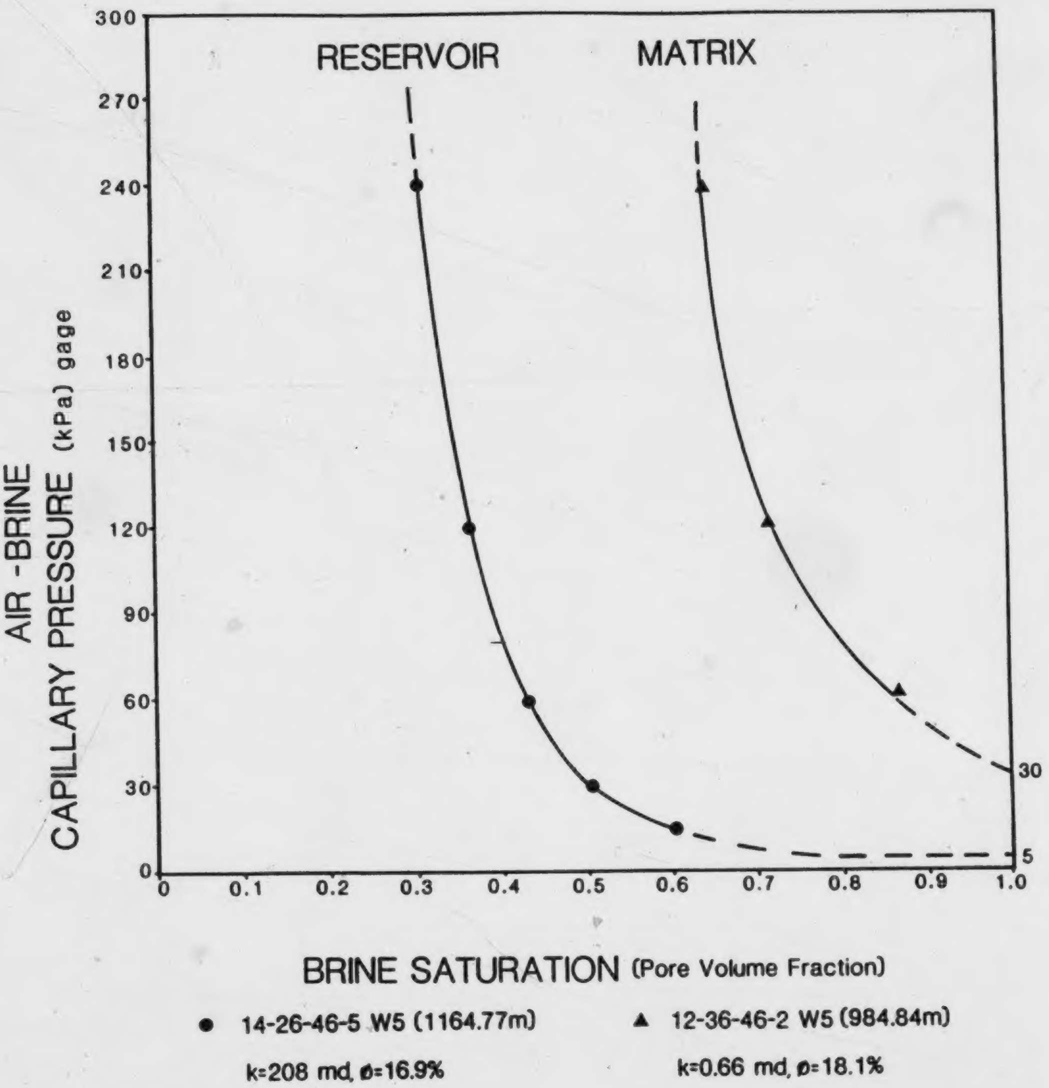


Figure 4.7: Air/Brine capillary pressure curves (source: AERCB).

Typical formation pressures in the Belly River Formation are subhydrostatic (Parks, 1989), that is, the pressures are less than would be expected, as compared to the pressure generated by a column of water equal in height to the depth of the particular point of comparison. Formation pressures in the lower portion of the Belly River Formation (just above the Basal Sand) are between 9100 and 9800 kPa (Parks, 1989).

At these typical temperatures and pressures, Belly River oil samples have viscosities (Figure 4.8) between 0.5 and 1.2 mPa·s (1.0 mPa·s = 1.0 centipoise). At 55 ^{o}C, water has a dynamic viscosity of approximately 0.5 mPa·s (Streeter and Wylie, 1981). The contrast between the oil and water viscosity ranges from 1:1 up to 2:1. With this contrast in mind, water and oil viscosities of 1.0 and 2.0 mPa·s respectively, were selected.

At the reported formation temperatures, water density is approximately 985 kg/m^3. For simplicity, a water density of 1000 kg/m^3 was used in all simulations.

Analysis of oil samples at typical subsurface temperature and pressures yields large differences in oil densities (Figure 4.9). At 9500 kPa, oil densities range from 750 to 690 kg/m^3.

Oil density plays an important role in secondary migration, through the buoyancy force component of the total fluid driving-force. This portion of the driving force arises as a result of density differences between oil and

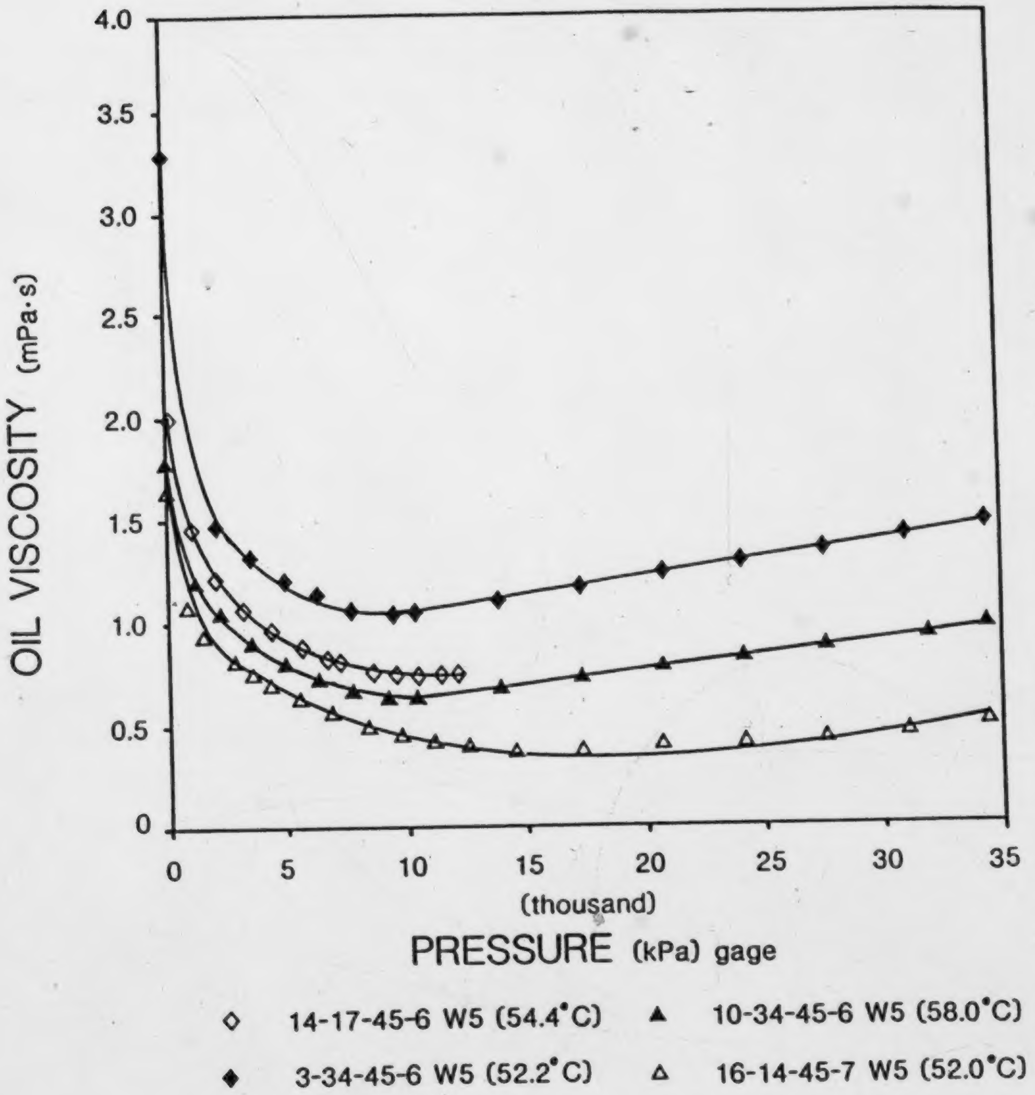


Figure 4.8: Oil viscosity versus pressure for four typical Belly River oil samples (source: AERCB).

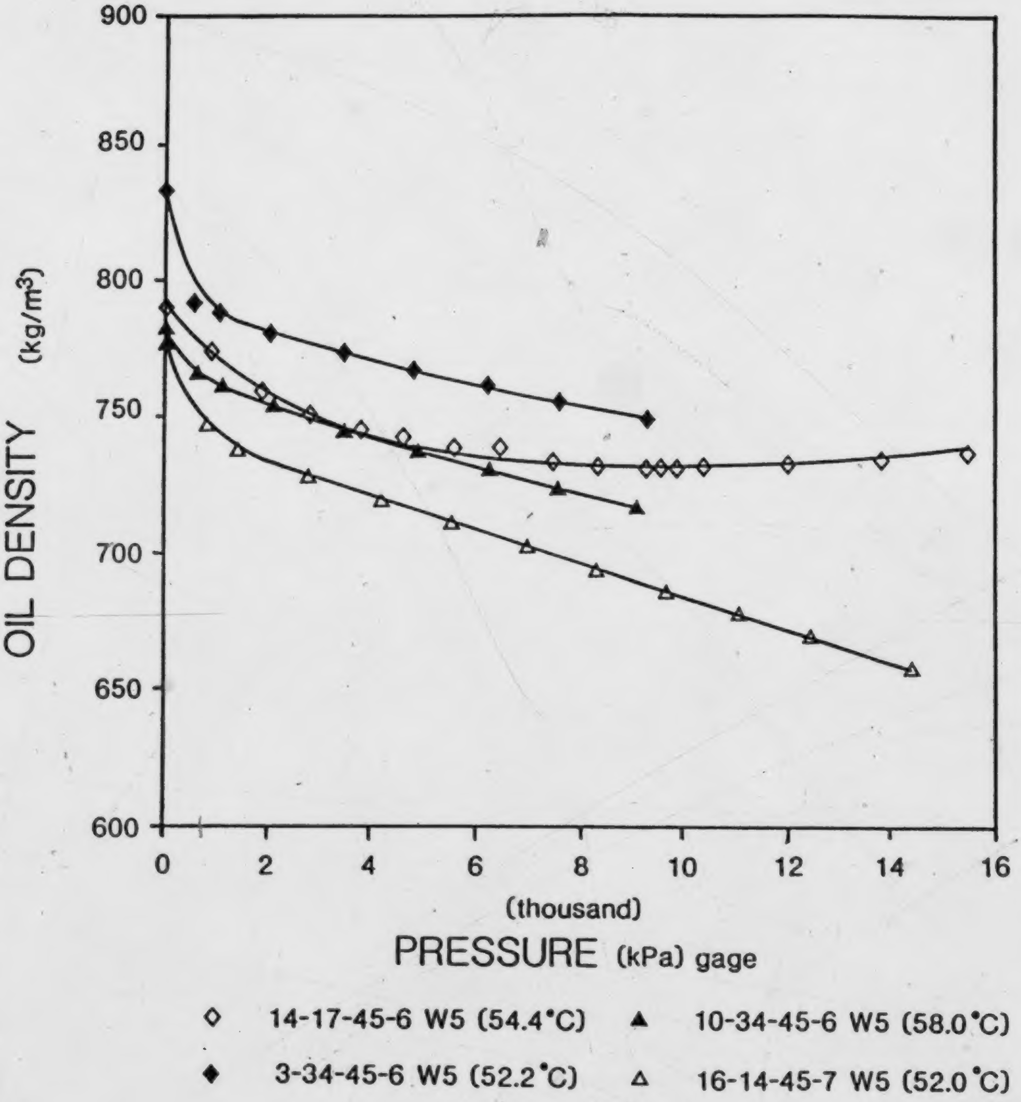


Figure 4.9: Oil density versus pressure for four typical Belly River oil samples (source: AERCB).

water. It acts opposite to the direction of gravity, with a magnitude in proportion to the density difference. To study this effect, two separate simulations were conducted using different oil densities.

The first simulation utilized equal (1000 kg/m^3, 10^o API) densities for oil and water, so as to isolate the effects of buoyancy on the oil potentiometric surface. The second simulation two was designed to study the migration of a medium crude oil (35^o API). A density of 850 kg/m^3 was used.

4.4 Initial Conditions

Input values for constant head boundaries and injection data were required for the simulations.

4.4.1 Fluid Potential Data

Within the interval of interest, in the primary data area, the regional fluid-potential gradient is approximately 0.02 metres/metre (Parks, 1989). As stated earlier, formation pressures range between 9100 and 9800 kPa. Using equation 2.3, these formation pressures can be converted to freshwater hydraulic heads of 606 and 642 metres respectively.

To produce a 0.02 metres/metre regional gradient over a 1250 metre long flow domain, a change in head of 25 metres is required. With this, and the typical formation hydraulic-heads in mind, the upstream and downstream water fluid-potential boundaries were fixed at 625 and 600 metres respectively.

All input pressure data were required to be specified in terms of oil pressure. Thus, the fixed water hydraulic-heads were converted, via equations 2.3 and 2.7, and the appropriate capillary pressure curve, and input as oil pressures.

4.4.2 Injection Data

To simulate secondary migration in the flow domain, a source of oil was required. This was achieved through the inclusion of a vertical row of oil "injectors" adjacent to the upstream constant head boundary. Feedstock fluids in a 90/10 water/oil ratio were introduced to the flow domain at a constant rate of $1.89 \cdot 10^{-2}$ m^3/yr (total combined injection). This value was input into the model in terms of fundamental units (kg-m-s) and was apportioned according to individual block volumes. Estimation of the this rate was difficult. Very few published cases exist listing specific rates and volumes of oil generated and moved during migration. Also, the accuracy and repeatability of these data are highly controversial. Therefore, the selection of the injection rate was made based on two other criteria.

The first criterion pertains to the potential disturbance caused during injection of the feedstock fluids into the flow domain. To minimize the increased pressure due to injection (similar pressure disturbance effect produced during production of a well) and its effect on the entire fluid-potential field, the injection rate was adjusted such that the maximum magnitude of the potential disturbance was less than 10 percent of the entire fluid-potential drop over the flow domain. The magnitude of the pressure disturbance was found to be directly related to the injection rate.

The second criterion deals with a more computational aspect of the simulations. If the injection rate were too high, the model would not converge at each timestep. Conversely, if the injection rate were too low, large amounts of time would pass before any visible migration would occur.

The selected injection rate was a compromise based on these two factors.

4.5 Simulation Control Parameters

Completion of the input dataset requires the specification of several parameters controlling the numerical model itself, which directly influence the accuracy of the results.

The timestep was specified to be 500 years, based on trial and error testing. Larger timesteps caused the model to diverge while smaller ones used excessive computer time. Constant time steps were utilized throughout, as the automatic increasing/decreasing timestep feature in the model yielded unsatisfactory results. Comparisons between large versus small timesteps, and equal versus unequal timesteps yielded no significant differences in the accuracy of the results.

The mass-balance tolerance (the maximum allowable percent error in the mass balance at any grid block during a timestep) was set at 0.01 percent, well below the recommended 0.2 percent (Faust and Rumbaugh, 1986).

The maximum number of Newton-Raphson iterations per timestep was set equal to five. This was the recommended value (Faust and Rumbaugh, 1986) and was found to be acceptable. Larger values did not help the simulations. If the solution had not converged within five iterations it usually would diverge.

4.6 Computer Implementation

These data were combined and input into SWANFLOW-2D. A wide variety of computers were used in this study, including microcomputers (IBM/XT, IBM/AT, Compaq DESKPRO), a mainframe (Amdahl 5870), and a supercomputer (CYBER 205). Results of "time trials" conducted on the various computers are summarized in Table 4.3. The microcomputers, although the cheapest, proved to be too slow. Furthermore, due to the relatively small amount of random access memory (RAM) available with these machines (approximately 600 kilobytes), sufficient lens-area detail could not be obtained. The mainframe computer could provide adequate lens-area detail (approximately 15 to 35 vertical grid blocks), but with these memory allocations the simulations proved too costly.

Table 4.3

Simulation costs and execution speeds for various grids on selected computers.

Grid size (#blocks hor/vert)	Memory (kbytes)	Machine	Cost (dollars/ timestep)	Speed (CPU secs/ timestep)	Comments
36 / 10	450	IBM/AT	0	320	
		AMDAHL	.35	.587	normal prio.
		CYBER	1.30	2.58	JDEFAULT "
		CYBER	.09	2.58	STANDBY "
80 / 50	14200	CYBER	N/R	N/R	mem. probs.
80 / 45	11705	CYBER	66.22	76.48	JDEFAULT
		CYBER	4.73	76.48	STANDBY
70 / 35	6401	AMDAHL	34.11	16.19	normal prio.
65 / 25	3200	AMDAHL	7.44	6.06	normal prio.
60 / 15	1206	AMDAHL	1.25	1.78	normal prio.
60 / 30	4130	AMDAHL	14.09	9.50	normal prio.
		CYBER	15.24	18.23	JDEFAULT "
		CYBER	1.09	18.23	STANDBY "

The supercomputer could provide excellent lens-area detail (up to 50 vertical grid blocks), but at these memory allocation levels, the simulations were again, too costly. A compromise grid (30 vertical grid blocks) that would run at a very high speed was selected. The simulations presented in sections 5.0 and 6.0 were run on the University of Calgary's CYBER 205 supercomputer.

The CYBER 205 at the University of Calgary operates under the Virtual Storage Operating System (VSOS) and is set up with one scalar and two vector-parallel, pipelined processors with 32 megabytes of available memory.

This system is capable of processing speeds up to 400 million floating-point operations per second (MFLOPS). The original FORTRAN 77 program was transferred to the CYBER, minor input/output modifications made, then compiled with the CYBER's FORTRAN 200 (CYBER FORTRAN 77) fully automatic vectorizing compiler. With this compiler and with no structural code changes, approximately 20 percent vectorization was achieved.

Central processing times (CPU) for the entire simulations were approximately 50 and 25 hours, for cases one and two, respectively. These very long times were due to the fact that full coefficient matrix was stored in memory and solved with a direct solution scheme. The estimated processing speed was approximately 2.5 MFLOPS. The total costs (on STANDBY priority) of the simulations were approximately 6400 and 3200 dollars, for cases one and two, respectively.

Output was obtained, at a minimum of every 250,000 years, in both hardcopy and plot-file form. Results presented were generated in two ways: first, the results were contoured by hand to ensure accuracy; then the output plot files were transferred to the University of Alberta's Amdahl 5870, then contoured and machine plotted using SURFACE II (Sampson, 1978).

5.0 CASE ONE - OIL DENSITY 1000 kg/m^3

This simulation was conducted in four parts: (1) steady state; followed by (2) transient oil/water injection; followed by either (3) transient water injection; or (4) transient migration.

The steady state phase is characterized by the absence of oil in the flow domain. At the end of this part, the fluid-potential patterns for oil and water are unchanging with time. Anomalous fluid-potential patterns have been developed to their fullest extent from the original, undisturbed, regional fluid-potential pattern.

Part two begins with the introduction of the oil/water mixture into the flow domain. At time equal to zero, the feedstock fluids are injected into the upstream end of the flow domain, adjacent to the upstream constant-head boundary. With time, oil migrates towards the lens and the downstream end of the flow domain. Associated with the changing hydrocarbon distribution are distinct and characteristic changes in the oil and water fluid-potential fields.

After the lens has been filled with oil, parts three and four begin, albeit separately. For Case One, both of these parts begin at 2.5 million years and end at 2.75 million years, respectively, after the start of oil injection.

Part three is characterized by the elimination of the oil component in the injected fluids, while a constant total injection rate is maintained. The injected fluid is 100 percent water, simulating the effect of "water washing" on a previously emplaced oil deposit.

Part four is conducted simultaneously but separately from part three. The two parts differ with regard to their fluid injection component. Whereas the injection fluid consisted of 100 percent water in part three, in part four there is no injection at all. Part four was conducted to study the period after the end of primary migration.

A portion of a computer output for part one is included in Appendix 2.

5.1 Oil Saturation

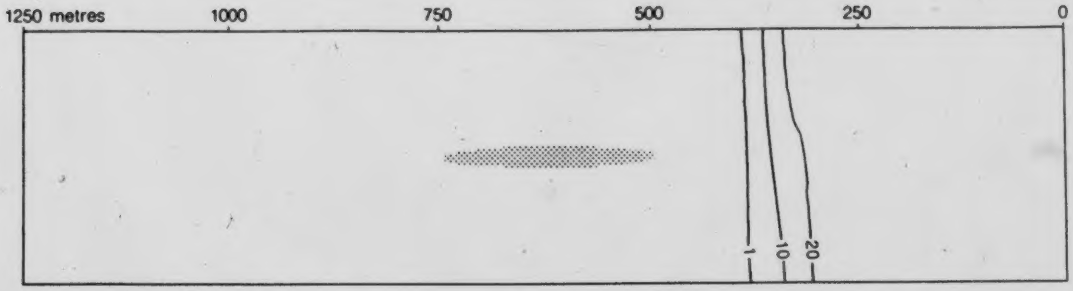
The boundary between the oil saturated/non-saturated portions of the flow domain is defined, and illustrated in all figures as the one percent contour of oil saturation. For this study, oil saturations less than one percent can be considered zero, for three reasons. First, there is a finite value of accuracy to the results, controlled by the mass-balance tolerance. Second, with the finite-difference technique, the true "zero" saturation contour is situated between two nodes at the advancing oil front. Because, values of zero saturation also exist in front of this "zero" saturation contour, the position of the "zero" contour is meaningless. Third, the "zero" and one percent values are so closely spaced in all cases, that they can be considered coincident.

The evolution of the oil saturation distribution through time is illustrated in Figure 5.1.

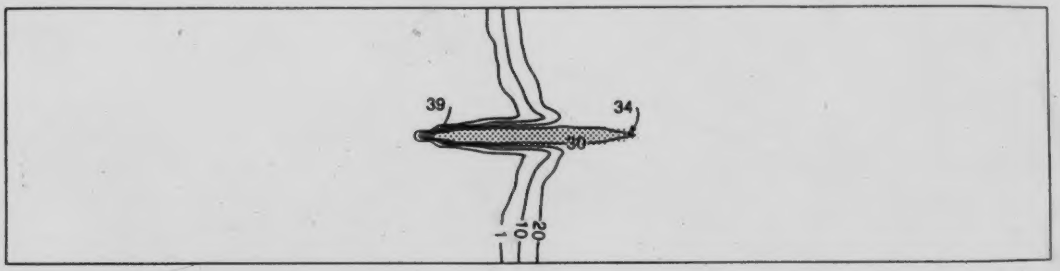
After 500 000 years, oil has not yet reached the lens. It is evident that oil must fill the pore space to a critical, lower level of oil saturation (in this case approximately 20 percent) before it migrates further downstream into previously oil-free pore space. The magnitude of this critical, lower level is determined by the particular value of S_{oi} obtained from the relative permeability curves for the formation of interest.

The transition zone between the oil-saturated and non-saturated portion of the flow domain is defined as the region between the 1 and 20 percent oil saturation contours. At 500 000 years the width of the zone is approximately 100 metres. This width results directly from the grid block spacing at the location of the zone. As the spacing of the grid blocks change within the flow domain, the width of the transition zone will change also. This can be seen at 1.5 million years (Figure 5.1b), where the zone is approximately 50 metres wide. This result is a function of the block-centered, upstream-weighted, simultaneous-solution technique used in the finite-difference flow model. It is unavoidable and typically a problem using numerical models of this type.

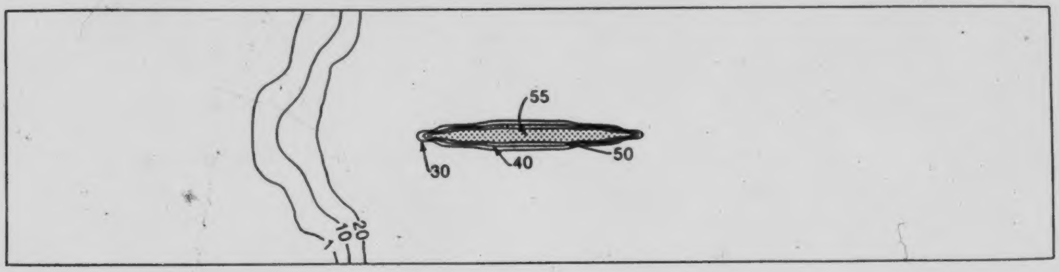
The non-vertical attitude of the iso-saturation contours is also a result of the solution technique used in the model. Considering the mass-balance tolerance (0.01 percent) over 30 grid blocks in a vertical direction, a difference in



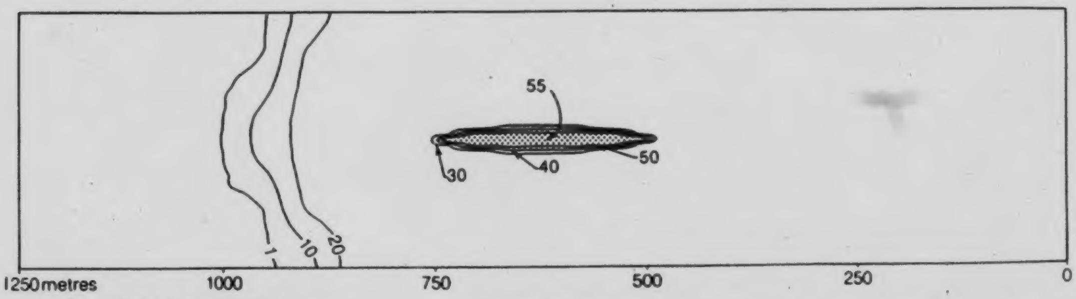
(a) 500 000 YEARS



(b) 1 500 000 YEARS



(c) 2 500 000 YEARS



(d) 2 750 000 YEARS

Figure 5.1: Oil saturation distribution, Case One. Contours in percent oil saturation.

saturation between the top and bottom grid blocks (in a vertical slice) could be 0.3 percent. This difference causes the non-verticality of the contours.

Once oil reaches the higher permeability lens (at approximately 1.0 million years), it advances preferentially within the lens, ahead of the transition zone in the carrier bed. For example in Figure 5.2, at 1.375 million years, the transition zone is located at the midpoint of the flow domain outside the lens, while inside the lens, it has already reached its downstream boundary.

The process of oil concentration within the lens begins at 1.375 million years. Oil enters the lens upstream and flows within the higher-permeability lens towards the downstream end. Fluid-potential conditions (to be discussed in the next sections) prevent oil from exiting the lens at this time; hence, oil concentrates within.

The lens acts as a trap, allowing water to flow through, while retaining and concentrating the oil within.

Concentration of oil within the lens can be seen at 1.5 million years (Figure 5.1b). Within the lens, oil saturation has reached a maximum of 39 percent, adjacent to and inside the downstream boundary of the lens. Throughout the rest of the lens, oil saturation decreases, to a minimum of 34 percent near the upstream boundary of the lens. This differential concentration can be attributed to the entrapment process which is retaining the oil within the lens. Oil is retained within the lens by fluid-potential

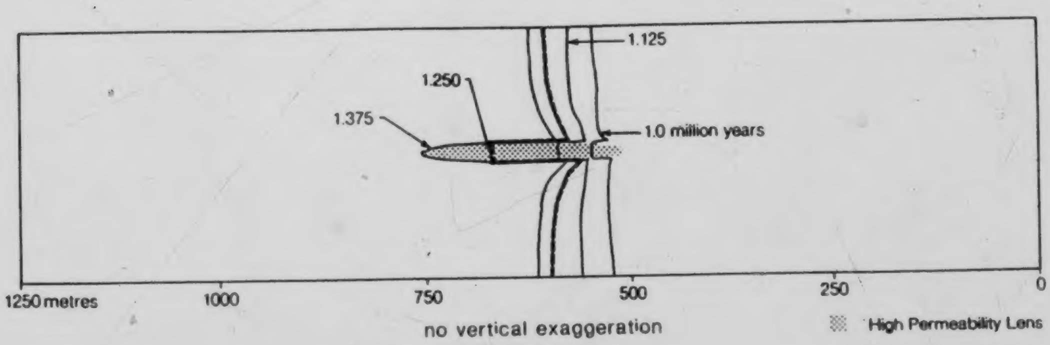

1.125
1.250
1.375
1.0 million years
1250 metres
1000
750
500
250
0
no vertical exaggeration
▨ High Permeability Lens

Figure 5.2: Evolution of the 20 percent oil saturation contour from 1.0 to 1.375 Million Years, Case One.

conditions that exist at the downstream boundary. The increase in oil concentration begins at the downstream end, and progresses gradually upstream as time passes.

Between 1.5 and 1.775 million years, oil fills the reservoir, gradually attaining 55 percent (pore volume) saturation throughout. At this point in time oil saturation in the reservoir reaches its maximum value. This maximum value is imposed by the irreducible water saturation, which can be determined from the relative permeability curves.

Once oil has reached its maximum saturation value (i.e., the lens has been filled) it begins to exit from the reservoir at the downstream end, into the matrix unit. Oil appears to enter the lens upstream at the same rate it exits downstream, thus maintaining the observed 55 percent saturation throughout (Figure 5.1c). Once the lens is filled, only the position and shape of the transition zone change with time.

The shape of the transition zone, once past the lens, is a function of its two sources of oil: a forward convex, bulbous end, sourced from inside the lens; and the original, near vertical shape, outside of the lens.

At 2.5 million years (Figure 5.1c) conditions in, and in the vicinity of, the lens are essentially at steady state with respect to saturation changes. The transition zone is located approximately 200 metres downstream from the lens, and is almost completely distorted from its near-vertical shape. Continued oil injection at this time would only result in further migration of the saturation front towards the downstream end of the flow domain.

Once the oil saturation conditions of Figure 5.1c were reached, part three of the simulation was initiated. The oil component of the feedstock fluid was set to zero to simulate the natural "water-washing" of a previously emplaced oil deposit.

The saturation distribution at the end of part three is illustrated in Figure 5.1d. After 250 000 years of "water washing" the transition zone has moved 50 metres downstream but the saturation distribution in the lens remains unchanged.

The oil required to move the transition zone 50 metres downstream has come from a slight rearrangement of the saturation distribution behind the front. Up to 2.5 million years, there was a uniform 27 percent oil saturation behind the transition zone. Water injection has caused an unevenly distributed, slight decrease in this value.

Part four, conducted to study the effect of the discontinuation of the source fluids, is analogous to the end of primary oil migration. During part four, the already existing fluids migrate under the influence of the initial regional hydraulic gradient. After 250 000 years of these conditions, the oil saturation distribution is essentially unchanged from that shown in Figure 5.1d.

At this time, discontinuation of the hydrocarbon supply has had no effect on the saturation distribution within the lens. The oil remains in place, even after the supply has stopped.

5.2 Water Hydraulic Head

The steady state hydraulic-head distribution for water is illustrated in Figure 5.3. The pattern shows the characteristic perturbation of the fluid-potential field caused by a highly-permeable lens situated within the flow domain. Flow is focused into the upstream end of the reservoir (613, 614, 615 metre contours) and spread out of the reservoir at the downstream end (610, 611, 612 metre contours). The maximum calculated potentiometric anomaly for this case is $^{+}/_{-}$ 2.4 metres, located at the downstream, and upstream tips of the lens respectively. Fluid-potentials in areas distant from the lens are unaffected by its presence.

This result was compared to results obtained using the analytical solution to the single-phase flow problem developed by Tóth (1962), and the United States Geological Survey Modular Groundwater Flow Model, MODFLOW (McDonald and Harbaugh, 1983). Both methods resulted in the same steady-state water hydraulic-head pattern as that obtained using SWANFLOW-2D.

At the start of oil injection, extra energy (as a result of injection) is added to the system producing locally increased values of fluid-potential. In this case, an extra hydraulic head of approximately three metres was added to the system. This disturbance was minimized as much as possible by

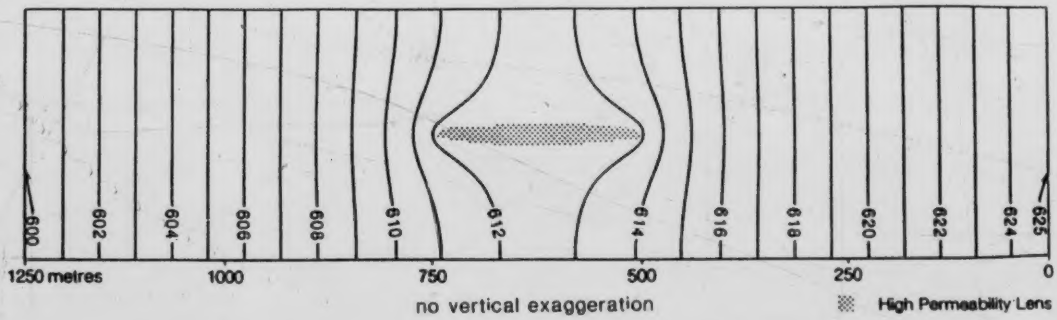

600
602
604
606
608
610
612
614
616
618
620
622
624
625
1250 metres
1000
750
500
250
0
no vertical exaggeration
High Permeability Lens

Figure 5.3: Water hydraulic-head distribution, Steady State conditions, Case One and Case Two. One metre contour interval.

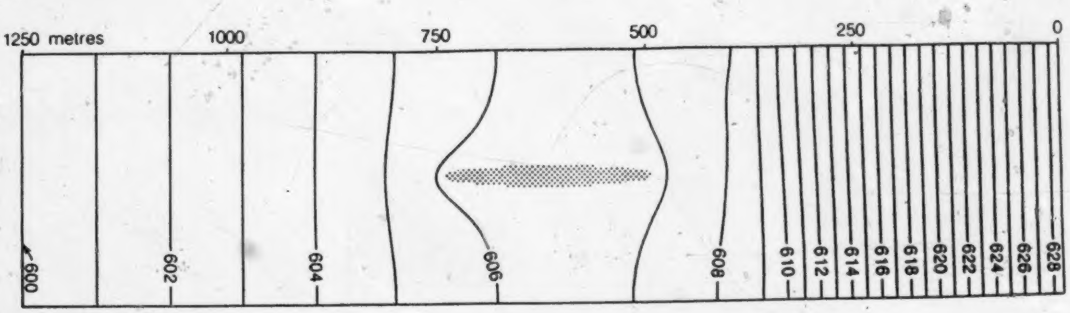
the selection of an appropriate flow rate, as discussed earlier. This shift in fluid-potential values precludes a quantitative comparison between steady-state and subsequent transient fluid-potential distributions.

Figure 5.4 illustrates the spatial and temporal evolution of the water hydraulic-head surface during part two of the simulation.

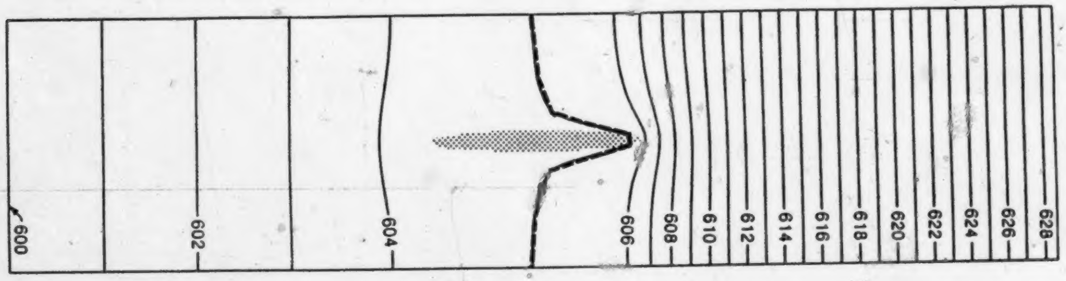
In the oil saturated portion of the flow domain, iso-potential contours are tightly serried, representing the requirement of increased energy for water movement at that degree of saturation. Outside the oil saturated portion of the flow domain, the hydraulic head contours show neither the effect of oil saturation, nor the highly-permeable lens. In this region, they are evenly spaced such that, through a series of equal potential drops, the fixed head boundary condition at 600 metres is met.

Initially, the overall shape of the anomalous zone is similar to the steady state pattern. At 500 000 years (Figure 5.4a), the upstream end of the anomaly is distorted owing to the proximity of the oil saturated region.

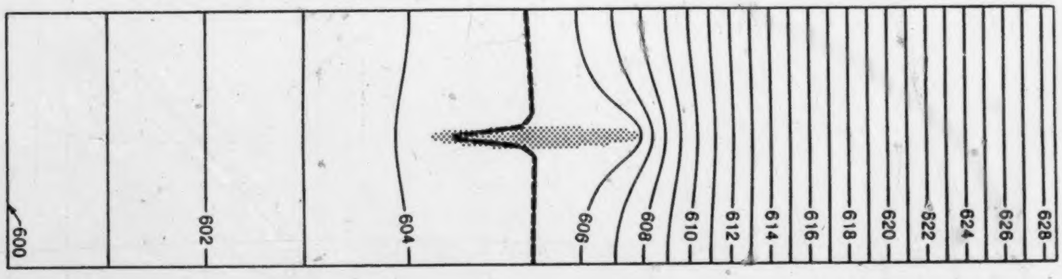
The asymmetry of the anomalous zone increases as oil nears the lens. At 1.0 million years, (Figure 5.4b) the degree of asymmetry is illustrated by the difference between the upstream (e.g., 605 metre) and downstream (e.g., 604 metre) contours which outline the shape of the anomalous zone. Water flow is strongly focused into the lens, as shown in Figure 5.4b.



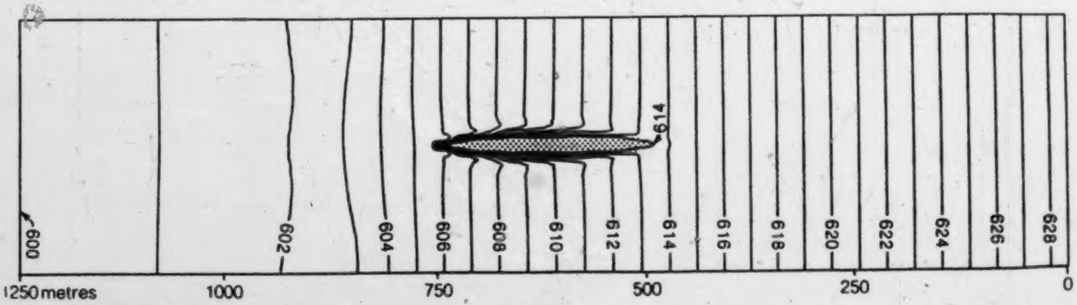
(a) 500 000 YEARS



(b) 1 000 000 YEARS



(c) 1 500 000 YEARS



(d) 2 500 000 YEARS

Figure 5.4: Water hydraulic-head distribution, Case One. One metre contour interval.

Once oil begins to enter the lens, the lens starts to lose its ability to focus flow. This occurs because as oil saturation increases, the relative permeability to water decreases.

As oil enters the lens and flows past it in the matrix, the asymmetry of the anomalous zone continues to evolve. This evolution is shown, for example, by the 605 metre contour in Figure 5.4c. Between 1.0 and 1.5 million years, the contour has "flipped" from the upstream to downstream sides of the lens, respectively. Furthermore, the 606 metre contour in Figure 5.4c is more tightly bent than in Figure 5.4b, and it is ready to flip over to the downstream direction.

In general, the asymmetrical pattern in the lens area results from the combination of the high-permeability effect and an areally-variable reduction in this effect due to increased oil saturation. Increased oil saturation causes decreased relative permeability to water. The decrease is non-uniform because of an uneven oil distribution within the lens.

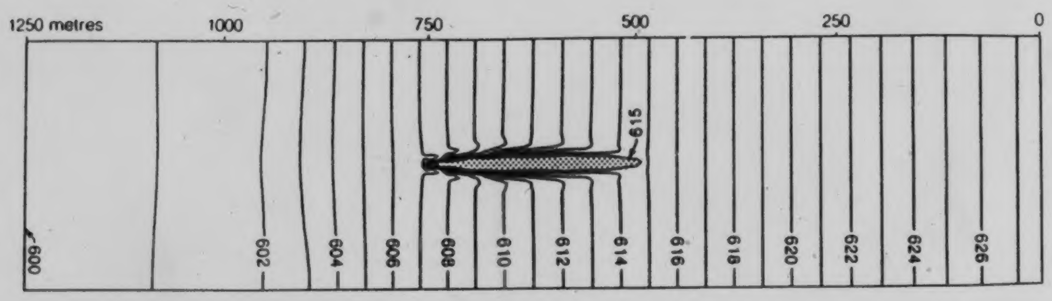
After approximately 1.8 million years, the water fluid-potential pattern in the area of the lens does not change because saturation conditions remain constant there.

At 2.5 million years the combined effects of oil saturation and a highly-permeable lenticular reservoir on the fluid-potential distribution are shown Figure 5.4d. Within the lens' boundaries, hydraulic head values of approximately 614.9 metres are found. This represents a local energy high, indicating the potential for flow out of the lens. This local high which, for all intents and purposes, is a closed potentiometric mound, precludes the possibility of water flow into the lens. Water must flow in the carrier bed around the lens. This is a complete reversal of the function of the once highly-permeable reservoir. Once filled with oil, the lens acts as a low permeability body placed in a highly-permeable flow field. This causes a major change in the potentiometric anomaly, which can be seen, for example by comparison of the 613 metre contour in Figures 5.3 and 5.4d. In Figure 5.3, water is being drawn into the reservoir; in Figure 5.4d it is being forced around and away from the reservoir.

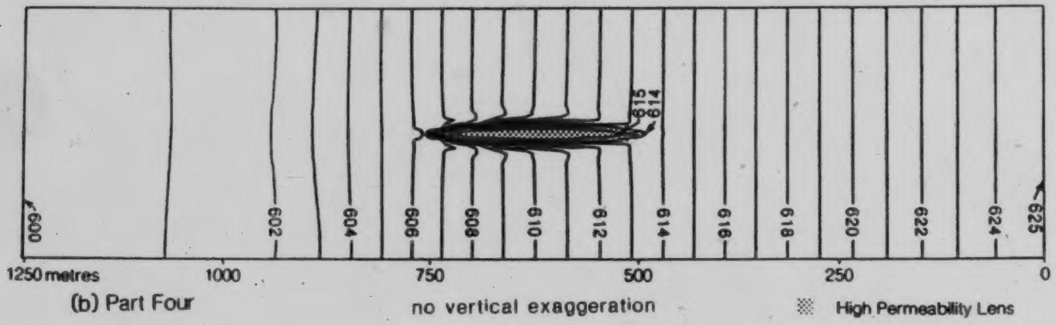
The persistence of the potentiometric mound during parts three and four can be seen in Figure 5.5, a and b respectively. After 250 000 years of waterflooding, the water fluid-potentials have adjusted to the new saturation conditions. Oil saturation in the carrier bed has been reduced, resulting in increased permeability to water. This results in a wider spacing of the equipotential lines in those zones.

At the end of part three, hydraulic head values within the lens are approximately 615 metres (Figure 5.5a). These values are caused by a slight adjustment to the new saturation conditions within the flow domain.

The fluid-potential distribution at the end of part four is illustrated in Figure 5.5b. Overall, the hydraulic head values have decreased as a result of the lack of injection



(a) Part Three



(b) Part Four

Figure 5.5: Water hydraulic-head distribution at 2 750 000 years, Case One. One metre contour interval.

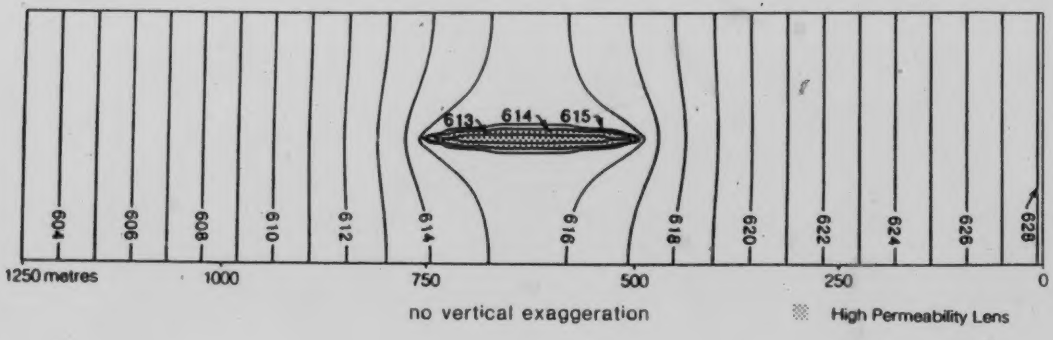
during this time period. The entire pattern has adjusted to the original 600 and 625 metre boundary conditions, similar to that shown in Figure 5.1.

5.3 Oil Hydraulic Head

The oil hydraulic-head distribution at steady state is shown in Figure 5.6. Although the shape is similar to the water hydraulic-head pattern (Figure 5.3), two major differences are evident.

The first difference is that the oil hydraulic heads are greater than the water hydraulic heads. This is due to the wettability of the formation. The Belly River Formation is strongly water-wet (Hunter, 1966) as discussed earlier. From equation 2.7, pressures, thus hydraulic heads, are greater in the oil phase than in the water phase (at any given saturation level). At 100 percent water saturation, pressure differences (obtained from the capillary pressure curves) between the oil and water phases are 5.0 kPa and 30.0 kPa, for the high and low permeability units, respectively (Figure 4.7). If converted to equivalent hydraulic heads using equation 2.3, these pressures add 0.51 and 3.06 metres to the water hydraulic-head values in the high and low permeability units, respectively.

The second difference between the oil and water hydraulic-head patterns is that the oil hydraulic heads form a closed potentiometric low within the lens, whereas no closed low exists on the water potentiometric surface. The


613
614
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606
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610
612
614
616
618
620
622
624
626
628
1250 metres
1000
750
500
250
0
no vertical exaggeration
▩ High Permeability Lens

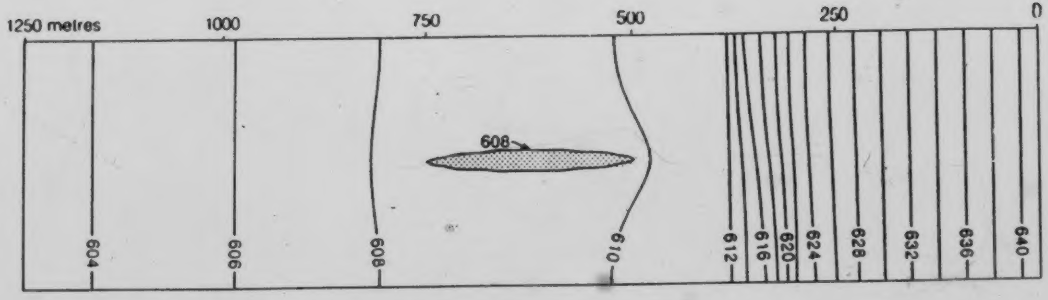
Figure 5.6: Oil hydraulic-head distribution, Steady State conditions, Case One. One metre contour interval.

development of a potential minimum is due to the difference between the high and low permeability units' capillary pressure curves (at 100 percent water saturation), combined with the effect of the highly-permeable lens on the water fluid-potential distribution. At this saturation condition (zero oil) the closed low illustrates the conditions for the entrapment of any oil particles that enter the lens.

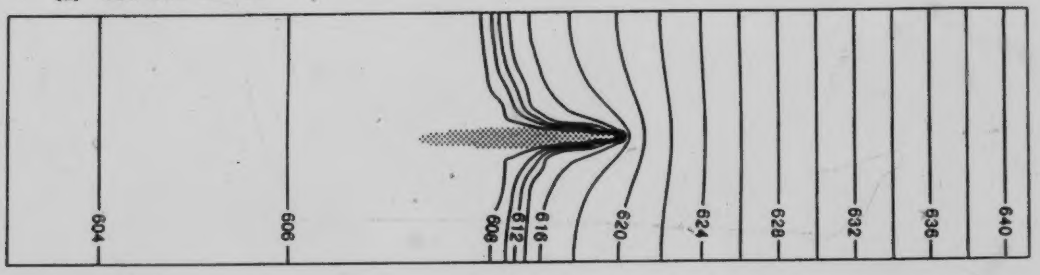
The evolution of the oil hydraulic-head surface during the oil/water injection phase is shown in Figure 5.7. At the onset of injection, as for the water hydraulic-head pattern, there is an increase in the total energy in the system. This results in a corresponding increase in the hydraulic head values.

In the oil saturated portion of the flow domain, the difference between the oil and water hydraulic heads is approximately 12 metres in the oil saturated zone, compared to approximately 3 metres in the non-saturated zone. This difference is caused by changes in capillary pressures between the phases resulting from altered saturation conditions.

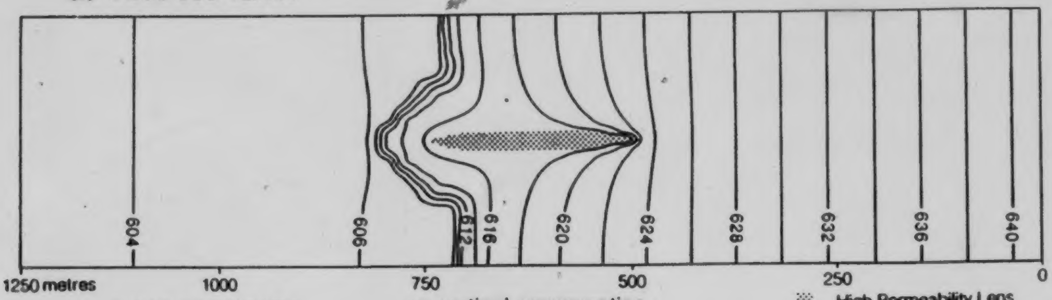
At 500 000 years (Figure 5.7a), the closed potentiometric low has a value of approximately 606.8 metres of hydraulic head. In the lower permeability unit, adjacent to the lens, hydraulic head values of approximately 609.2 metres occur. The difference in these values (2.39 metres of head or 23.422 kPa) represents an energy or pressure barrier that must be overcome by oil to exit from the lens. This


1250 metres
1000
750
500
250
0
608
604
606
608
610
612
616
620
624
628
632
636
640

(a) 500 000 YEARS


604
606
608
612
616
620
624
628
632
636
640

(b) 1 500 000 YEARS


604
606
612
616
620
624
628
632
636
640
1250 metres
1000
750
500
250
0

(c) 2 000 000 YEARS

no vertical exaggeration
▨ High Permeability Lens

Figure 5.7: Oil hydraulic-head distribution, Case One. Two metre contour interval.

value represents the dynamic sealing capacity of the downstream boundary. Oil enters the lens at its upstream end, but is prevented from exiting downstream until the fluid-potential conditions change. These conditions can be altered by increased oil saturation reducing the capillary pressure forces acting to retain the oil in the lens.

The potentiometric surface for a partially filled lens is shown in Figure 5.7b. Two important features dominate the pattern.

First, strongly focused oil flow into the reservoir is indicated by the 608 to 622 metre contours which are tightly serried around the upstream end of the lens. At the downstream end, the opposite is true. Oil is still being trapped in the lens by the presence of the potentiometric barrier located there.

Second, the capillary pressures, and thus fluid-potential conditions, in the vicinity of the lens have changed as a result of increased oil saturation within the lens. Inside the lens, hydraulic heads are approximately 606.4 metres. Immediately outside they are approximately 607.4 metres. The capillary force barrier due to the difference in these potentials is still present, but has been reduced in size from 2.39 to 1.0 metre of head (23.422 to 10.388 kPa). Oil is still unable to exit from the lens, a condition which will continue until further saturation changes occur.

By 2.0 million years, the reservoir has been filled. Oil emplacement has had a major effect on the oil hydraulic-head pattern observed at this time (Figure 5.7c). The reservoir is now acting as a highly-permeable body (to oil), similar in nature to the steady-state potentiometric surface for water. This can be seen by the shape of the anomalous (614 to 624 metre) contours in Figure 5.7c.

Oil is able to exit through the downstream end of the lens because increased oil saturation in the lens has resulted in the disappearance of the downstream potential barrier. The capillary barrier will be zero when the fluid pressures are equal across the lithologic boundary. At zero oil saturation in the matrix, a capillary pressure difference of 30.0 kPa exists (Figure 4.7). This value of capillary pressure (30.0 kPa) is equaled when the oil saturation in the reservoir reaches 50 percent. This means that, for these particular capillary pressure curves (Figure 4.7), oil is not held in the reservoir by capillary forces past 50 percent oil saturation. Oil continues to concentrate in the lens past 50 percent, to 55 percent saturation because the effect of the lower intrinsic and relative permeabilities outside the lens must be overcome. That is, it is still easier for the oil to concentrate in the lens past 50 percent oil saturation, rather than exit into the lower permeability unit.

During parts three and four, saturation conditions change very little within the flow domain, which is reflected by essentially unchanged hydraulic-head distributions.

The maximum value of hydraulic head decreases from 640.8 to 636.3 metres during part three (not illustrated), as the potentials adjust to the new saturation conditions.

For part four (Figure 5.8), the overall pattern has adjusted to the reduction in energy, and to the changes in saturation distribution. No other major features are evident.

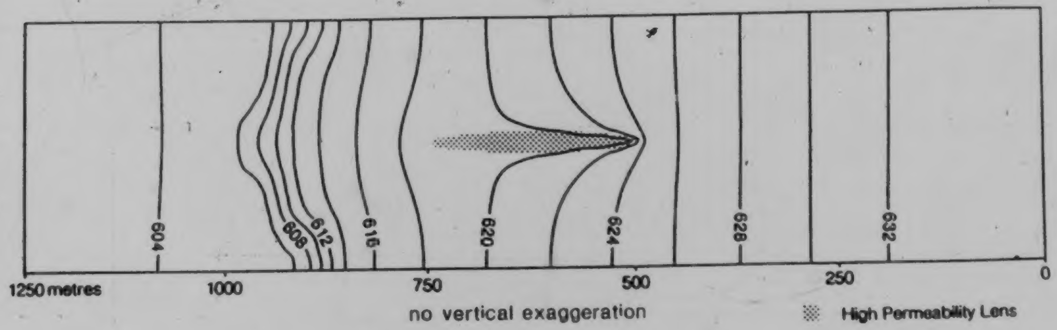

604
608
612
616
620
624
628
632
1250 metres
1000
750
500
250
0
no vertical exaggeration
High Permeability Lens

Figure 5.8: Oil hydraulic-head distribution, at 2 750 000 years, Case One. Two metre contour interval.

6.0 CASE TWO - OIL DENSITY 850 kg/m^3

This simulation was conducted in two sequential parts, similar to the first two parts of Case One. First, steady state conditions were established throughout the flow domain. Second, oil was injected at the upstream end of the system, simulating the onset of secondary migration.

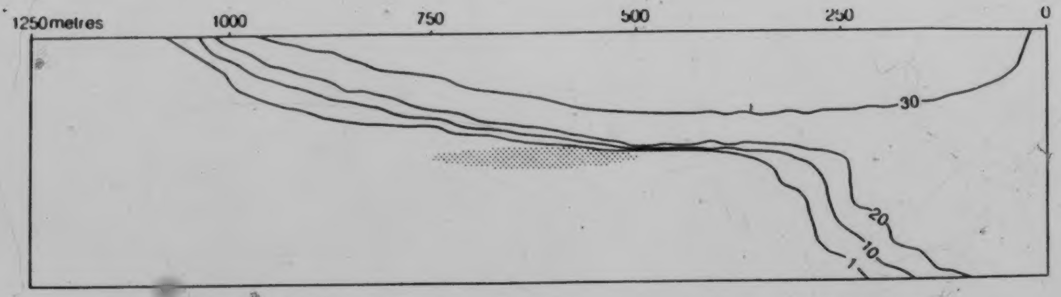
A portion of a computer output from part one is included in Appendix 3.

6.1 Oil Saturation

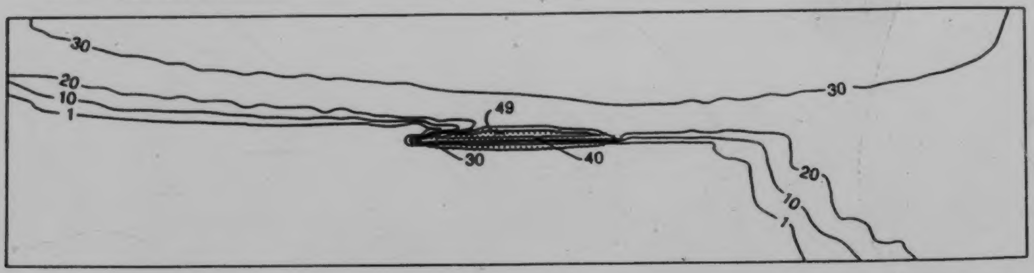
The spatial and temporal evolution of the oil saturation distribution is shown in Figure 6.1. The overall saturation pattern is markedly different from Case One, in three general ways.

First, oil migration and entrapment progressed at a much slower rate. After 1.0 million years (Figure 6.1a), oil has yet to reach the lens, although it had by this time in Case One. The amounts of oil injected after 1.0 million years are equal for both cases. The observed dissimilarity results from the density difference between the injected oils. In this case, instead of travelling downstream, a portion of the oil is migrating upwards and concentrating along the top of the low permeability unit.

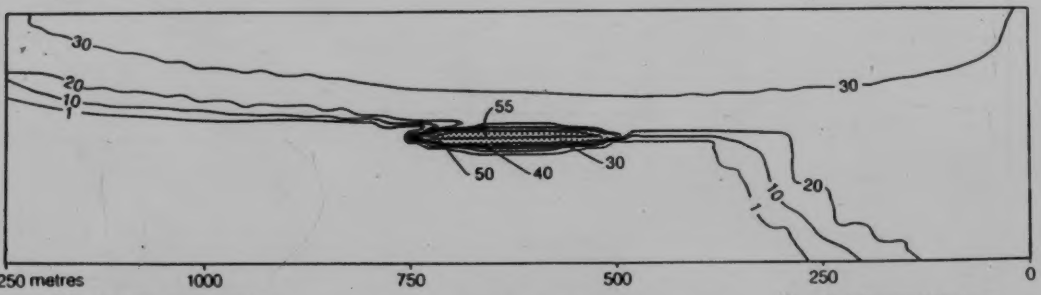
Second, the degree of oil saturation in the low permeability unit is higher in Case Two. This is by far the most significant difference. Oil saturation has reached 37



(a) 1 000 000 YEARS



(b) 3 000 000 YEARS



(c) 5 000 000 YEARS

Figure 6.1: Oil saturation distribution, Case Two. Contours in percent oil saturation.

percent (pore-volume) along the top of the low permeability unit, compared to a maximum of 27 percent, attained in Case One. Oil is entering the system and moving vertically as well as downstream, concentrating at the upstream boundary of the flow domain. It is easier for the oil to move vertically, and to concentrate, than to move downstream into previously non-saturated portions of the flow domain.

Third, the shape of the transition zone has changed. In both cases, the boundary between the saturated and non-saturated portions of the system is a narrow band with a very steep saturation gradient. As a result of oil migrating upward and along the top of the low permeability unit, the transition zone has extended much further downstream in the current case than in Case One. Furthermore, the width of the boundary region does not change as it moves downstream across the grid.

Oil begins to enter the lens at approximately 1.1 million years. It enters the lens through the top upstream "corner", from two directions, namely: from above, and laterally upstream from the saturated portion of the low permeability unit. Once within, oil migrates downstream towards the uppermost, downstream "corner" of the lens.

Oil does not begin to concentrate (i.e., increase saturation beyond 20 percent) within the reservoir; instead it spreads and contacts previously non-saturated reservoir pore-space. This is caused by fluid-potential conditions that exist in the area of the lens, which will be discussed in a later section.

Concentration of the oil within the reservoir begins before the entire pore volume of the reservoir is contacted. For example, at 4.0 million years oil has just contacted the entire reservoir space but oil has concentrated to 53 percent saturation along the upper boundary. The effect is similar to the observed saturation distribution in the matrix unit, where the oil concentrates along the upper boundary rather than migrating into non-saturated portions of the matrix.

As time progresses, the lens continues to fill from the upper, upstream "corner". At 3.0 million years (Figure 6.1b), oil saturation has attained a maximum value of 49 percent along the top of the reservoir. The process of initial downstream filling and concentration, followed by concentration towards the upstream end of the reservoir, occurs because oil is retained in the reservoir at the downstream boundary by a combination of capillary and hydrodynamic forces.

At 5.0 million years the simulation had to be stopped because oil began concentrating at the downstream end of the flow domain. Past 5.0 million years, oil began to flow back upstream. This spurious concentration was caused by the inability of the oil to migrate further downstream due to the presence of the grid boundary. The results up to the start of the spurious accumulation remain valid.

The final saturation distribution is shown in Figure 6.1c. Oil saturation has reached 55 percent, the limiting value imposed by the relative permeability curves, along the top 5.0 metres of the reservoir. Elsewhere in the reservoir, oil saturation varies from 38 to 55 percent.

Differential concentration of the oil is evident in the horizontal direction. Combined with the already existing vertical segregation, this produces tilted iso-saturation lines within the reservoir (Figure 6.2). The maximum oil saturation is observed at the upper, downstream position in the lens, with saturation values decreasing rapidly in any vertical section and less rapidly in any horizontal section.

Oil has continued to enter the lens upstream, but has started leaking out the downstream end. The downstream leakage occurs at a very slow rate. The net result is the observed, continued concentration within the reservoir. Oil saturations of up to 14 percent exist outside the reservoir because changes in fluid-potential conditions allow for some oil leakage from the reservoir. The reasons for this will be discussed further in section 6.3.

Based on filling rates for the past 5.0 million years, it is estimated that if injection were continued at the same rate, oil saturation would reach 55 percent in all areas of the lens by 6.0 million years. Therefore, under the assumed conditions, this reservoir would require approximately 5.0 million years to fill with oil.

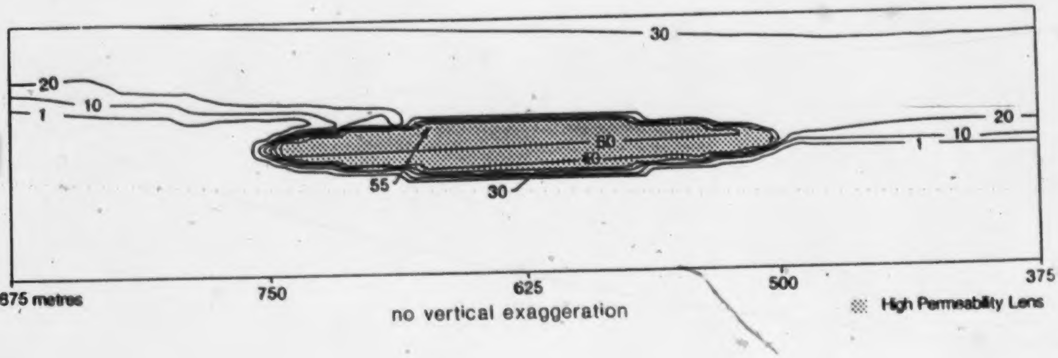


Figure 6.2: Detail of lens-area oil-saturation distribution at 5 000 000 years, Case Two. Contours in percent oil saturation.

6.2 Water Hydraulic Head

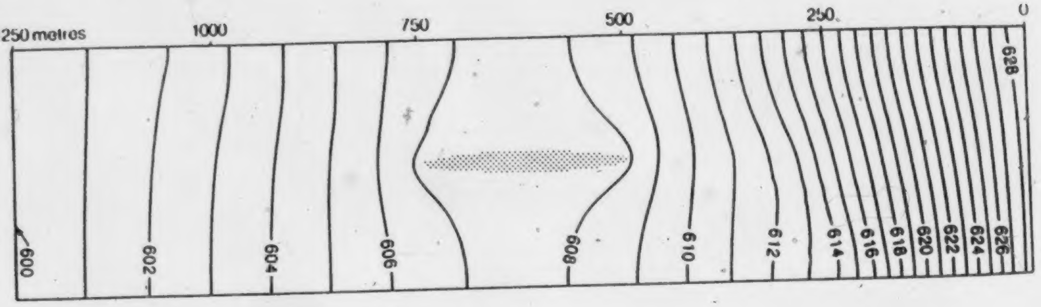
The steady state, water hydraulic-head distribution for Case Two is exactly the same as for Case One because the same water density and initial conditions were used in both cases. Figure 5.3 illustrates this pattern, of which a detailed explanation has been given in section 5.2.

The evolution of the water hydraulic-head surface during part two of the simulation is shown in Figure 6.3.

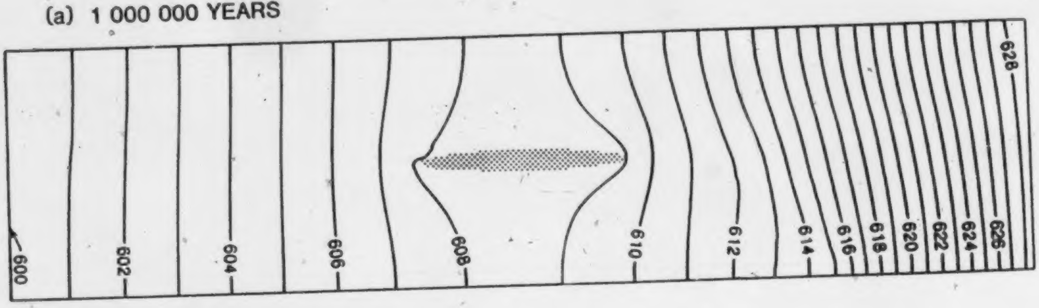
At the start of oil injection, the maximum value of water hydraulic head in the system increases, similar to that observed in Case One, because of the extra energy added to the system from fluid injection.

Overall, the hydraulic head patterns show two effects of increased oil saturation within the flow domain. First, the contours outlining the lens area are asymmetrical. This is caused by increased oil saturation in the top portion of the grid and within the lens (at later times), altering the direction of fluid-flow, and hence the fluid-potential pattern. Second, a visible difference exists between the shape of the hydraulic head contours upstream and downstream of the lens. The hydraulic head contours downstream of the lens are almost vertical. Upstream, the contours are not vertical. This illustrates the variable sensitivity of the hydraulic head pattern to changes in oil saturation.

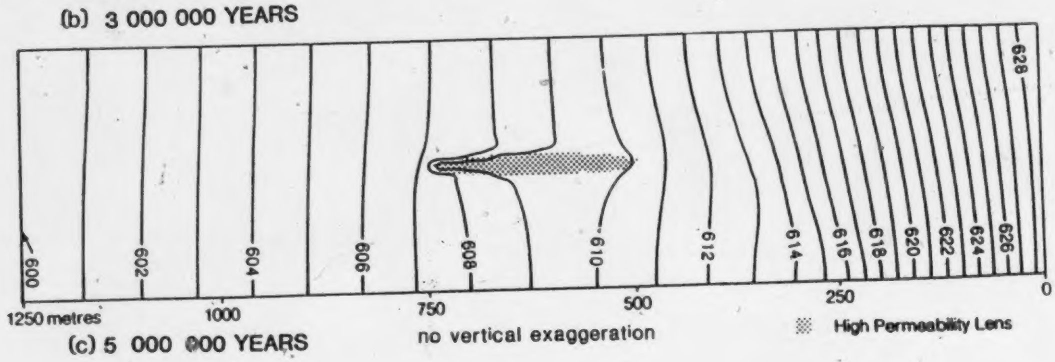
The variable effect upstream/downstream of the lens can be explained by changes in oil saturation distribution. In both cases, there is a vertical in oil saturation gradient



(a) 1 000 000 YEARS



(b) 3 000 000 YEARS



(c) 5 000 000 YEARS

no vertical exaggeration

Figure 6.3: Water hydraulic-head distribution, Case Two. One metre contour interval.

across the flow domain. Upstream, the saturation varies from approximately 27 to 35 percent (bottom to top), which causes non-vertical hydraulic head contours. Downstream, the saturation varies from 0 to 30 percent, with no noticeable effect on the hydraulic head distribution. Therefore, subtle changes in saturation may or may not cause changes in the water fluid-potential patterns, depending on the position on the relative permeability curves where these changes take place.

The position of the transition zone is difficult to predict from these water potentiometric surfaces. The extent of the hydrocarbon saturated portion of the flow domain is hinted at by a slight bunching of the contours at the upstream end of the flow domain. It is interesting to note that the presence of oil shifts the contour values only 2.5 metres, a shift that could well be mistaken for the effect of another highly-permeable but non-saturated body nearby.

At 3.0 million years (Figure 6.3b) a small portion of the lens has reached 49 percent oil saturation, reducing the relative permeability to water in this area to near zero. Water is now being forced to flow around this area, which is reflected in the shape of the 608 metre contour. This effect is localized, and not noticeable elsewhere.

At 5.0 million years, the top 5.0 metres of the lens has reached 55 percent oil saturation, hence zero permeability to water. Water is starting to flow around that part of the lens. This effect is visible on the hydraulic head pattern in

Figure 6.3c. The iso-potential contours (608 to 610 metres) have begun to encircle the top 5.0 metres of the lens. This is the beginning of the isolation of that particular low permeability region from the rest of the flow domain. If the entire reservoir had reached zero relative permeability to water, it would be encircled by closed region of high fluid-potential, causing migrating water particles to flow around it, similar to the situation that existed after 2.0 million years in Case One.

In Case Two, asymmetrical water flow into, and around, the lens is indicated. This occurs because the relative permeability to water has not been reached zero throughout the lens. The non-uniform decrease in permeability has caused an asymmetrical fluid-flow pattern which is reflected in the shape of the hydraulic head contours in the lens area.

6.3 Oil Hydraulic Head

The distribution of oil hydraulic head at steady state is shown in Figure 6.4a, and in detail in Figure 6.4b. Hydraulic heads are higher than in Case One. This is due to a difference in oil density between the two cases, which can be explained by the comparison of two hypothetical fluids A and B. Applying equation 2.3 to A and B (where A is less dense than B) will result in higher hydraulic heads for fluid A, at the same point of measurement. This calculation, which illustrates the difference between hydraulic head values in cases one and two is contained in Appendix 4. It contains a

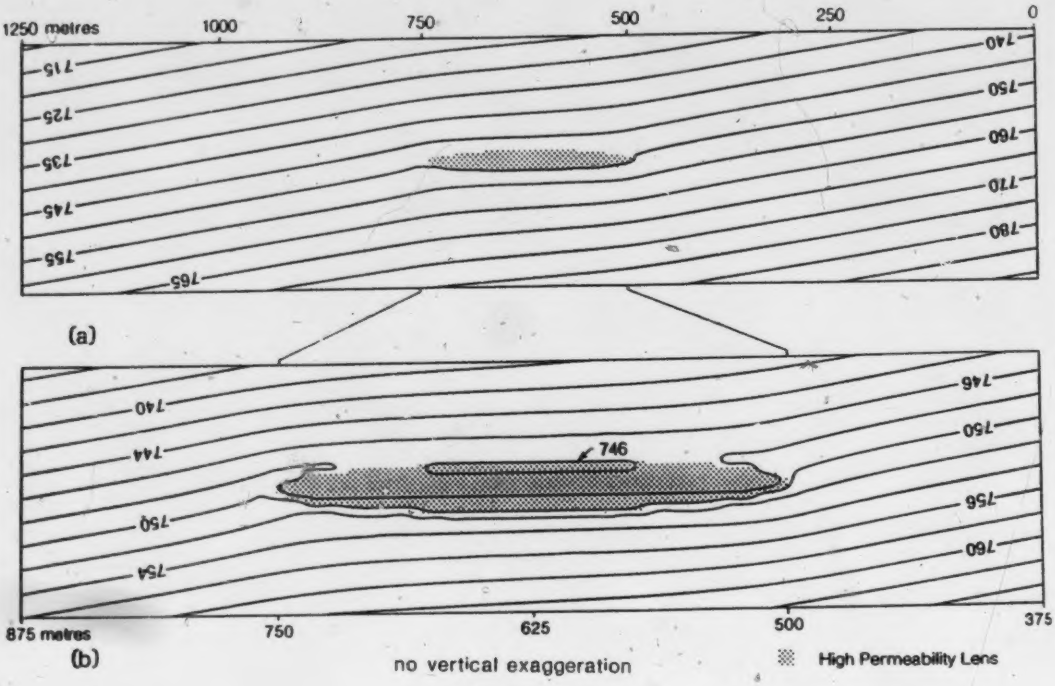


Figure 6.4: Oil hydraulic-head distribution, Steady State conditions, Case Two.
(a) Five metre contour interval
(b) Lens-area detail. Two metre contour interval.

sample calculation of an oil hydraulic-head value from a given water hydraulic head at a point near the upstream boundary of the flow domain.

The oil hydraulic-head pattern (Figure 6.4) is made up of three separate, but inter-related effects, namely: (1) buoyancy; (2) a highly-permeable lens; and (3) capillary pressures.

The buoyancy effect is clearly visible outside the lens area in Figure 6.4a. The tilted iso-potential contours are a result of the vector summation of the two separate driving forces on the fluid particles. For oil, in a hydrostatic environment, the driving force vector is vertical. For water, in a hydrodynamic environment the driving force vector is horizontal. The vector summation of these two forces yield the driving force vector for oil in a dynamic environment, namely that seen outside the lens area in Figure 6.4a. The iso-potentials resulting from a combination of lighter oil and flowing water are termed the buoyancy effect.

The highly-permeable lens effect, cannot be isolated from figures 6.4a or 6.4b, due to the insufficient resolving power of the 5.0 and 2.0 metre contour intervals. This effect arises because the permeability contrast between lens and matrix causes flow to focus into the upstream, and out the downstream, ends of an elliptical, highly-permeable rock body (Tóth and Rakhit, 1988). From results obtained in Case One (identical lens properties), the highly-permeable lens effect generates a maximum of +/- 2.4 metres difference in hydraulic head, at the downstream and upstream ends of the lens, respectively.

The capillary pressure effect arises from differences in the capillary pressure curves at 100 percent water saturation. This effect acts normal to the lens boundary. Its magnitude can be calculated as the difference in the capillary pressures (at 100 percent water saturation) in the lens and matrix. In this instance, the magnitude equals 25.0 kPa or 3.0 metres of hydraulic head. This effect acts across the lens boundary and is directed inwards, from the matrix to the lens.

In Case Two, the summation of the buoyancy, highly-permeable lens, and capillary pressure effects does not produce a symmetrical, closed potentiometric-low, such as that seen in Case One.

Figure 6.5 is a schematic breakdown of the forces acting in the lens area. This figure is an interpretation of the simulated hydraulic-head distribution (Figure 6.4a). Six areas of interest are shown, numbered clockwise from the upper, upstream "corner" of the lens.

At steady state, oil flows into the lens from all directions. The resultants of the three force components are all directed inwards, although each vector has a different magnitude. At position 1, the capillary and permeability components override the buoyancy component. Oil flow is downstream (with respect to water) and downwards into the reservoir. At position 2, all three components are directed

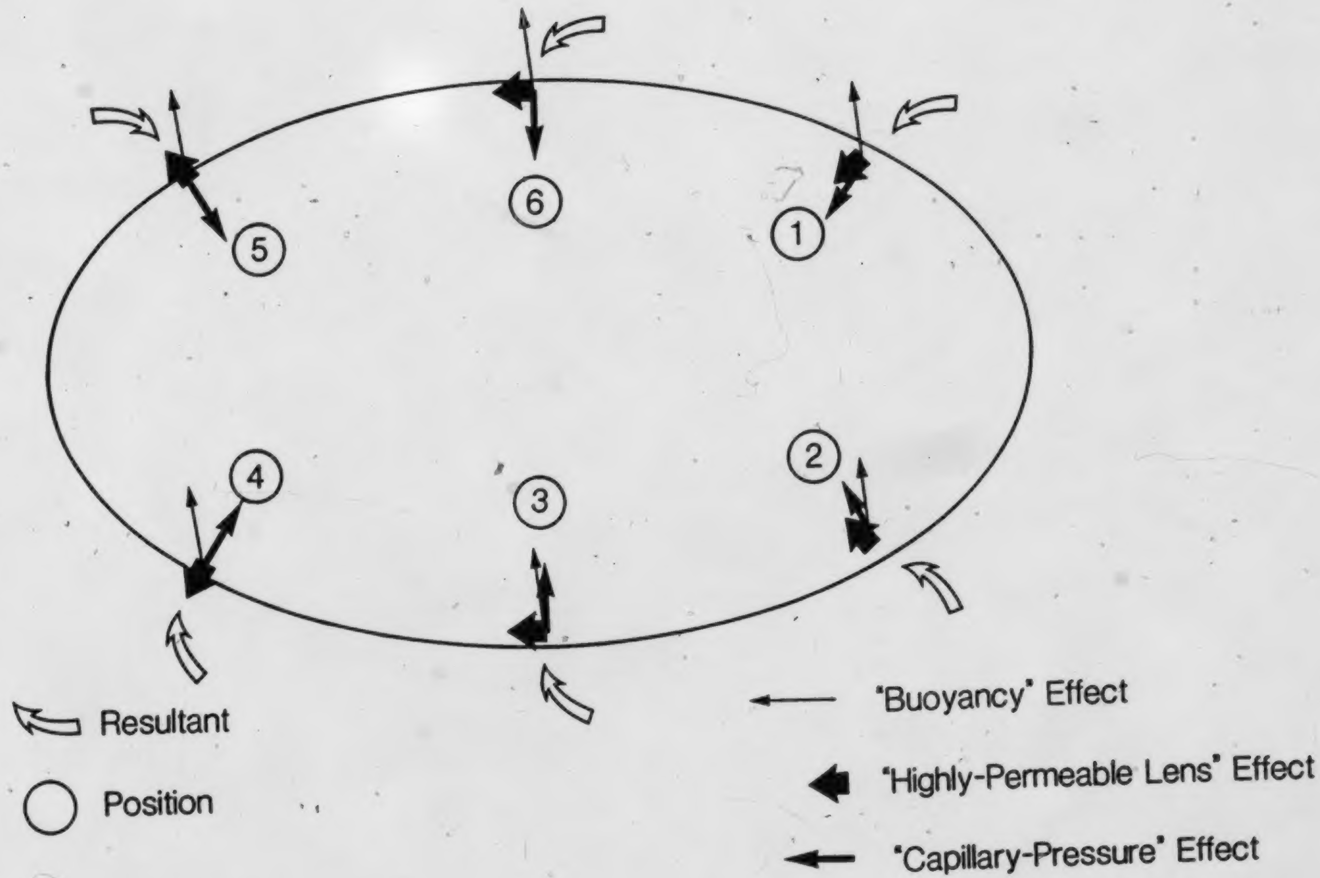

1
2
3
4
5
6
Resultant
Position
'Buoyancy' Effect
'Highly-Permeable Lens' Effect
'Capillary-Pressure' Effect

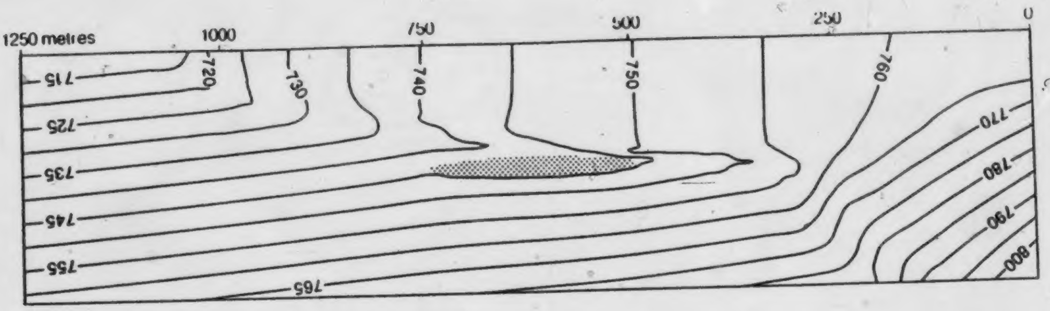
Figure 6.5: Schematic of forces acting in the area of the lens at Steady State conditions.

in towards the lens, creating the most favorable position for oil entry. At position 3, the capillary and buoyancy components combine to direct flow upwards into the lens. At position 4, the resulting oil flow is upwards into the reservoir, but upstream with respect to water. The capillary force and buoyancy components combine to control the oil flow direction. At position 5, the net result is similar to position 4, but is weaker because only the capillary force component acts to draw oil into the lens. This would be the most likely position for oil to exit from the lens. At position 6, the resultant is directed downwards because the capillary force component is larger than the buoyancy force component.

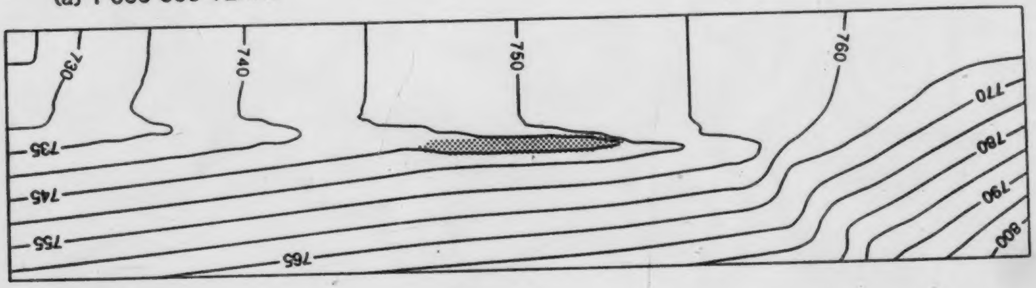
Figures 6.4 and 6.5 illustrate that oil entrapment in the reservoir is controlled by a complex super-position of buoyancy, permeability, and capillary derived forces.

The spatial and temporal evolution of the oil hydraulic-head surface during part two is shown in Figure 6.6. Details of the lens area at 1.0 and 5.0 million years are shown in figures 6.7a and 6.7b, respectively.

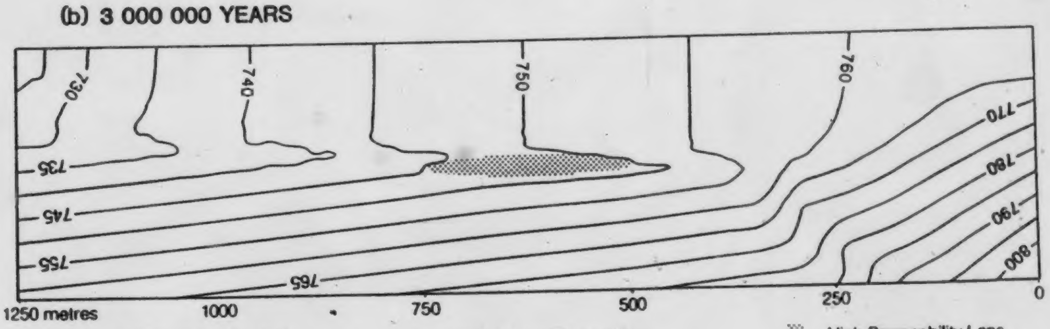
Outside the lens area, little change takes place in the hydraulic head surface during the 5.0 million year injection period. Upstream of the lens, oil flows upwards and downstream, as evidenced by the tilted contours in that region. Above the lens, oil flows horizontally downstream, as indicated by the near-vertical contour lines.



(a) 1 000 000 YEARS



(b) 3 000 000 YEARS



(c) 5 000 000 YEARS

no vertical exaggeration

▨ High Permeability Lens

Figure 6.6: Oil hydraulic-head distribution, Case Two. Five metre contour interval.

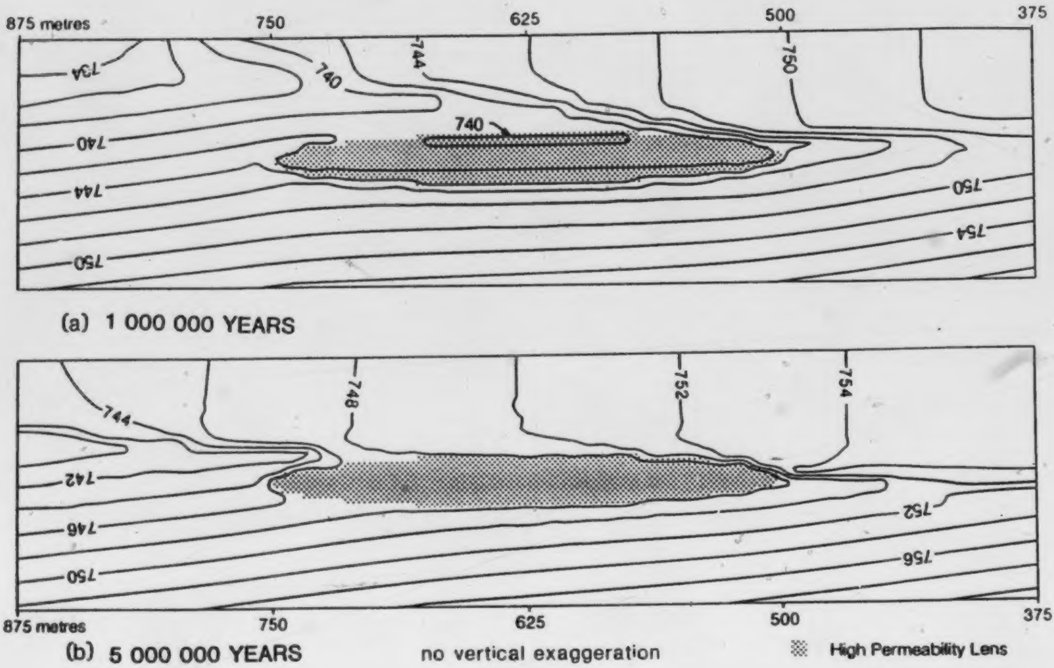


Figure 6.7: Lens-area detail of the oil hydraulic-head distribution, Case Two. Two metre contour interval.

Inside the lens, changes in the hydraulic head distribution take place as the lens fills with oil. At 1.0 million years (figures 6.6a and 6.7a) the pattern is similar to that at steady state. Oil is not yet entering the lens, but soon will be entering along the upper, upstream "corner" of the lens.

As oil fills the lens, the magnitude of the capillary pressure barrier changes. For example, by 2.0 million years (not illustrated) the capillary barrier will have been reduced from 3.0 to 1.4 metre of head. By the time 3.0 million years have elapsed, a portion of the lens has reached 50 percent oil saturation which is the point where capillary pressures are equal in the oil saturated lens and non-saturated matrix. This means that oil can leave the lens. This is visible in Figure 6.6b, where the 745 metre contour almost circles the entire reservoir, except for a small break at the "corner" of the lens (position 5 on Figure 6.5). Oil exits at a very slow rate into the low permeability unit. There is still a positive net flow of oil into the reservoir.

As time passes, the fully saturated portion of the reservoir grows in size. Associated with this is the loss of the reservoir's ability to trap oil.

The final hydraulic-head pattern is shown in Figure 6.6c and in detail in Figure 6.7b. On the regional scale there are distortions in the fluid-potential field but there is no direct indication of the presence of a lens. This is partly due to the use of a 5.0 metre contour interval, and partly as a result of lens filling causing decreased disturbance to the flow field.

The lens is now leaking from the upper, and upper-downstream boundaries (positions 5 and 6, Figure 6.5). Now, only a very minor, inward component of flow is indicated by the potentiometric surface. Oil is still focused into the lens but not nearly as strongly as before.

It is hypothesized that if injection were continued to the eventual saturation of the lens, by 6.0 million years the lens would be indistinguishable from the rest of the flow domain (based exclusively on the oil hydraulic-head distribution). Any further advancement in time would most likely produce oil hydraulic-head distributions similar to Figure 6.6c. After this time, the oil hydraulic-head pattern would likely remain unchanged.

7.0 DISCUSSION

7.1 Sensitivity Analysis

Typically, in a numerical simulation study such as this, the sensitivity of the results to changes in input parameters would be investigated. Such an analysis would normally be conducted by altering an input parameter, re-running the simulation, and comparing the results with the original case. This type of quantitative analysis was not possible in this study due to the large number of input parameters, and the length of time required to run each simulation. Instead, a qualitative discussion of the sensitivity of the results will be presented, based on simulations conducted, but not included here.

As mentioned previously, SWANFLOW-2D assumes constant values of fluid viscosity and density, that is, they are not allowed to vary as a function of pressure. The largest and smallest pressure values encountered at any time, in any position, in either case, were 9181 and 5916 kPa. These values occurred in Case Two, during the oil injection part, in the lower-upstream, and upper-downstream corners, respectively, of the grid. Tables 7.1 and 7.2 illustrate the oil viscosity and density variations over these pressures, which were obtained from PVT curves for Belly River Formation oil samples (figures 4.8 and 4.9). It can be seen that the total change in the parameters over this (maximum) pressure range, is small (1.9 and 3.9 percent for density and

Table 7.1

Oil viscosity variation over the range of pressures encountered in the simulations.

Well	Viscosity @ Pmin (mPa·s) (5916 kPa)	Viscosity @ Pmax (mPa·s) (9181 kPa)
03-34-45-06 W6	1.15	1.04
10-34-45-06 W6	0.80	0.625
16-14-45-07 W6	0.625	0.74
14-17-45-07 W6	0.88	0.74
average	0.864	0.786

range 0.078

percent variation 0.078/2.0 · 100 = 3.9 %

source : AERCB Pressure-Volume-Temperature (PVT) data file.

Table 7.2

Oil density variation over the range of pressures encountered in the simulations.

Well	Density @ Pmin (kg/m^3) (5916 kPa)	Density @ Pmax (kg/m^3) (9181 kPa)
03-34-45-06 W6	763	750
10-34-45-06 W6	730	710
16-14-45-07 W6	712	688
14-17-45-07 W6	738	731
average	735.8	719.8
range	16	
percent variation	$16/850 \cdot 100 = 1.9\ \%$	

source : AERCB Pressure-Volume-Temperature (PVT) data file.

viscosity, respectively) in comparison to the magnitude of the data values. In the strictest sense, these variations should be accounted for, but in this case, the additional computing time required to obtain more accurate results is not warranted.

The input data can be divided into three groups, based on their sensitivity: (1) data that control the operation of the simulation; (2) data that, when changed, have a minor effect on the outcome of the simulation; and (3) data that, when changed, have a major effect on the outcome of the simulation.

The first group are the simulation control parameters. Their effect(s) do not directly affect the outcome of the simulations. These were discussed in section 4.5.

The second group are defined as those data which have only a minor effect on the outcome of the simulations, relative to the data in group three that have a major effect on the simulations. Data in the second group include: grid and lens size/shape; number/shape of grid blocks; magnitude and ratio of fluid viscosities; ratio of fluid densities; magnitude and ratio of permeabilities; magnitude and ratio of porosities; oil injection rate; and gradient/magnitude of water fluid-potentials. Each of these data, if altered enough, could have a major, if not controlling, effect on the simulation results. However, the simulation results are not as sensitive to changes in the group two data as compared to the group three data. By increasing/decreasing one or more of these parameters, the results will be altered, but the alteration of the results is proportional to the change(s) made. For example, a small increase in the size of the lens will cause: slightly larger fluid-potential distortions; require the use of a larger grid; and lengthen the time required to fill the lens. The fluid-potential pattern will be of similar shape, and the lens will eventually fill with oil as before, but with a slightly longer filling time.

The third group include: fluid density; relative permeability curves; and capillary pressure curves. The simulation results were sensitive to small changes in these data.

The effect of changes in density on the simulation results become evident by comparison of cases one and two. The entire oil saturation distribution, and oil/water potentiometric surfaces are affected by a change in the fluid density. Furthermore, the oil flow direction outside the area of the lens is a function of the density difference between the fluids.

The critical parts of the relative permeability curves are their respective endpoint values, S_{oi}, and S_{wi}. These values control: the amount of residual oil left behind the front; the maximum attainable level of oil saturation; the minimum oil saturation required for oil flow; the ultimate oil recovery; and a number of other parameters. The shape of the curves themselves control the rate at which permeability to each fluid is affected by changes in saturation.

Simulation results are also very sensitive to changes in capillary pressure curves, which are critical as far as trapping of oil is concerned. Each of the three parts of the curve are important, namely: (1) the entry pressure (@S_w = 100%), to which the trapping capacity of the reservoir is directly related; (2) the shape of the middle part of the curve, which influences how rapidly changes in capillary pressures occur with changes in saturation; and (3) the shape of the "tail" ($S_w \cong S_{wi}$) portion of the curve which is related to S_{wi}, and the maximum attainable oil saturation.

It should be noted that laboratory-derived capillary pressure curves may not represent long term reservoir conditions. That is, that over a long period of time the wettability factors which control the shape of the capillary pressure curves may change. This could cause changes in the shape of the capillary pressure curve(s), which would cause the real conditions to differ from the simulated conditions.

The same long-term effect could alter the relative permeability curves. The possibility exists that, for example, the irreducible oil saturation may eventually reach zero. That is, long-term wettability changes or water washing could allow all of the oil to be removed from the pore space. This could explain why no traces (or "trails") of oil exist in carrier beds along known migration pathways.

These long term changes could be simulated by altering the relative-permeability and capillary-pressure curves at certain times during the simulation, but this would only serve to further complicate the fluid-potential patterns that are evolving as the simulation proceeds. For the purpose of this work, long term changes in the input data did not warrant investigation.

7.2 Effect of Oil on Potentiometric Surfaces

One of the original objectives was to study the oil and water potentiometric surfaces during oil emplacement, with emphasis on the degree and distribution of hydrocarbon saturation. Results presented here (figures 5.1 - 5.8, 6.1 - 6.4, 6.6 - 6.7), illustrate these effects. In general, the following are found:

(1) the water potentiometric surface in an oil-free environment is a function of the regional fluid-potential gradient, permeability contrast, lens geometry, and lens orientation relative to the regional fluid-flow direction.

(2) the oil potentiometric surface in an oil-free environment is a function of the water potentiometric surface, but is modified by the capillary pressure curves of the particular rock unit, and the density difference between oil and water.

(3) once oil is introduced into the system, both fluid-potential patterns begin to change, as a result of the functional relationship between oil saturation and permeability (relative permeability curves), and oil saturation and pressure (capillary pressure curves).

(4) the original, localized potentiometric low in the lens area is reduced as the lens fills with oil. As the lens

fills, its ability to trap oil is reduced. Eventually, once full, the oil potentiometric surface appears similar to the water potentiometric surface at steady state (with modifications for capillary pressures).

(5) for the water potentiometric surface, as emplacement and concentration progress, the relative permeability to water decreases. This is manifested in an alteration of, and eventually the destruction, of the fluid-potential anomaly.

(6) for intermediate cases, i.e., partially full lenses, the potentiometric surfaces for either fluid are difficult to interpret in terms of degree and distribution of oil saturation. That is, it is difficult to take a potentiometric surface from a flow domain containing partially filled lenses, and predict the degree and extent of the oil saturation. This is because too many variables combine to produce the fluid-potential surfaces. The solution of the inverse problem: from potentiometric surface to geology, is non-unique. Oil saturation cannot be determined with any degree of certainty, given only the water potentiometric surface.

7.3 Implications for Exploration

Previous work (Rakhit, 1987; Tóth and Rakhit, 1988) has illustrated that reservoir-quality rock bodies cause characteristic perturbations of the water potentiometric surface. The present study extends their analysis by including an oil phase in the flow domain. It illustrates the genetic relationship between lens, oil accumulation, and fluid-potential anomalies.

Earlier works have shown how Hubbert's UVZ method and single-phase potentiometric surface analysis can be useful for oil exploration (Dahlberg, 1982; Tóth and Rakhit, 1988). The present study investigates these methods further by accounting for oil in the reservoir, and the resulting reduction in permeability to water. It also accounts for the presence of oil, and includes capillary pressures in the flow domain.

The single-phase potentiometric-surface technique is hampered by the fact that, water potential surfaces are affected by the presence of oil. It is impossible, therefore, to differentiate between water-potential anomalies generated by low relative permeability to water or by low intrinsic permeability.

Figure 7.1 illustrates the proposed "iterative improvement process" that could be used for this problem. First, the geology of a flow domain is assumed, using where possible, information from other sources (geophysics, well logs). Next, the data are input into the numerical model, and a numerical UVZ analysis completed (such as shown in any of the oil/water hydraulic head figures). The simulated potentiometric surface can then be compared to the field-derived water potentiometric-surface. In this manner, various geological alternatives, and their resulting fluid-potential patterns can be generated and compared, in order to try and

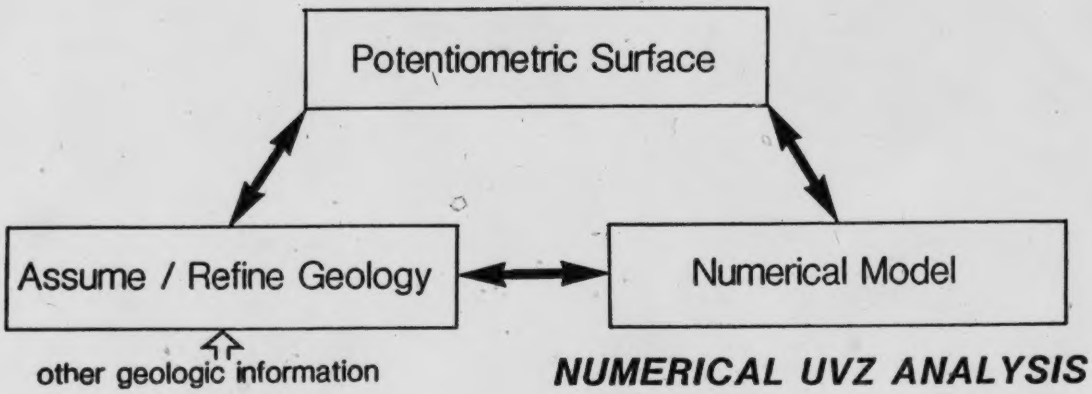

Potentiometric Surface
Assume / Refine Geology
Numerical Model
other geologic information
NUMERICAL UVZ ANALYSIS

Figure 7.1: Schematic of the proposed "iterative improvement process".

determine the geology and the degree and distribution of hydrocarbon saturation, i.e., whether an oil filled lens is present or not.

8.0 CONCLUSIONS

Numerical modelling has, in general, shown that:

1) It is possible to simulate secondary oil migration and entrapment in a lenticular reservoir, on a basinal scale, using currently (1989) existing software and computer hardware.

2) Fluid-potential fields of water and oil govern fluid flow directions, which are modified by:

    (i) highly-permeable lenses, situated within the flow field;
    (ii) buoyancy;
    (iii) capillary pressures.

3) The distribution of fluid-potentials is genetically related to relative permeability and capillary pressure curve properties which are, in turn, functions of oil saturation distribution. As migration proceeds, oil saturation distribution, thus fluid-potential distributions, change in time and space.

4) Entrapment of oil within a reservoir is controlled by fluid-potential conditions that are generated by regional fluid-potential gradients, and modified by super-position of the highly-permeable lens, buoyancy, and capillary pressure effects.

5) In certain cases, fluid flow is dominated by one or more of these effects. This can lead to opposing fluid flow directions.

6) Capillary pressures and relative permeabilities, which have not been taken into account in previous works, play a major, if not controlling, role in the migration and entrapment of oil in lenticular reservoirs.

Specific conclusions from the results fall into three categories, dealing with: oil migration and entrapment; potentiometric surface effects; and implications for oil exploration techniques.

Oil migration

- Medium gravity oil (850 kg/m^3) will tend to migrate in the carrier bed along the upper boundary with a less permeable rock. Under this condition, lenticular reservoirs can be charged with oil moving downward from above.
- Once a reservoir is filled with oil, it will remain so, even after the supply of oil is terminated. This is a direct result of fluid-potential and permeability relationships within the reservoir. Oil will remain trapped until fluid-potential conditions in the reservoir change (possibly through long term changes in the capillary pressure or relative permeability curves).

Fluid-potential effects

- Water-filled lenticular reservoirs are favorable sites for oil accumulations owing to favorable permeability and capillary pressure conditions. These reservoirs generate characteristic fluid-potential patterns.

- Oil preferentially enters and accumulates within a reservoir until the oil saturation level alters the fluid-potential conditions such that oil may exit. This happens through changes in relative permeability (to oil and water), and changes in capillary pressures inside and outside the reservoir.
- The reduction in relative permeability to water, as a result of increased oil saturation within a lens, can modify and even reverse, the highly-permeable lens effect.
- Since capillary pressure and relative permeability curves are strongly non-linear, the effects on fluid-potential conditions are highly sensitive to changes in saturation at certain saturation levels.

Oil exploration techniques

- It is difficult (if not impossible) in some cases, using the water potentiometric surface, to distinguish between an oil-saturated reservoir with high intrinsic permeability and a water-filled lens of low permeability. In these cases, it is mandatory to use other information, including: oil potentiometric surfaces; and other geological, geophysical, and chemical information in the exploration effort.
- Oil hydraulic-head surfaces, as shown, are analogous to Hubbert's U surface, accounting for capillary forces and the presence of oil.
- Numerically calculated oil potentiometric-surfaces (such as shown) are more accurate, more widely applicable, and easier

to calculate than Hubbert's U surface. As such, the numerical simulations presented here demonstrate the operation of the numerical UVZ method.

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Appendix 1

Results of waterflood tests on selected Belly River cores.

Well	S_{wi}	S_{oi}	por.	air perm.	commments
06-16-48-3 W5	31.9	26.8	17.7	228.	
	35.6	24.4	18.0	78.	
	45.8	21.8	17.3	33.	
	40.6	23.1	18.8	29.	
	58.7	26.9	15.6	5.3	
	49.2	28.4	13.6	4.4	
	58.2	17.8	14.9	3.8	
16-35-47-6 W5	46.5	32.4	14.3	0.8	
	41.6	30.8	13.2	0.45	
	58.2	29.7	13.6	0.53	
	47.9	37.4	14.1	0.41	
	47.9	32.0	14.8	0.89	
	53.9	31.1	14.1	0.18	
06-03-48-5 W5	55.8	24.2	18.0	12.8	
	48.5	29.8	18.5	35.3	
	59.8	28.8	14.5	0.93	
	65.9	28.8	14.7	0.80	
04-25-47-4 W5	49.6	17.9	14.3	3.07	
	64.4	7.0	16.3	12.0	
	64.6	12.1	16.3	39.3	
	56.2	15.3	15.6	4.54	
	56.1	31.8	16.0	6.35	
10-12-47-4 W5	39.7	29.7	16.4	114.	
	40.0	29.5	17.2	176.	
	42.0	29.8	16.2	7.8	
	39.8	29.0	16.9	35.0	
	85.0		13.0	.38	C-P test
	85.0		14.9	.33	"
	85.0		15.2	.51	"
	80.0		15.0	1.30	"
	35.0		18.1	250.	"
	40.0		18.5	105.	"
	35.0		19.6	260.0	"
	55.0		17.0	8.6	"
	40.0		18.7	59.0	"
	85.0		15.3	0.53	"
	80.0		15.9	1.32	"
	80.0		15.5	0.75	"

Well	S_{wi}	S_{oi}	por.	air perm.	commments
02-13-47-4 W5	43.0	31.0	16.3	24.0	
	48.0	31.0	13.9	11.0	
	51.0	30.0	16.3	4.7	
	43.0	30.0	16.2	31.0	
	42.0	29.0	13.5	8.8	
	85.0		13.9	0.31	C-P test
	88.0		14.1	0.14	"
	83.0		14.3	0.90	"
	28.0		16.9	56.0	"
	77.0		15.2	2.3	"
	70.0		16.5	3.6	"
	63.0		17.6	2.5	"
	58.0		17.8	10.9	"
	65.0		15.6	3.9	"
	53.0		15.9	6.1	"
08-12-48-3 W5	25.3		21.1	215.	"
	31.9		20.1	90.	"
	31.1		20.1	73.	"
	33.4		18.4	34.	"
	51.1		15.8	1.8	"
10-23-48-6 W5	38.0	26.0		79.	
10-15-48-6 W5	50.0	22.0		15.	
10-23-48-6 W5	52.0	15.0		5.3	
14-08-49-9 W5	30.0	42.0		1.41	
14-17-49-9 W5	32.0	28.0		256.	
	32.0	26.0		51.5	
14-34-47-2 W5	40.8	14.3	22.2	148.	
	46.8	13.8	19.6	60.	
	51.7	19.0	19.5	52.	
	55.4	19.4	18.2	23.	
	47.2	14.1	18.8	18.	
10-36-47-4 W5	39.0	17.9	21.0	379.	
	36.3	22.0	18.2	116.	
	45.3	24.8	18.0	68.	
	43.7	22.9	18.3	54.	
	46.0	23.5	18.0	27.	
	64.8	21.1	17.3	14.	
	56.7	19.7	15.0	5.8	
	55.5	24.7	16.0	2.6	

Well	S_{wi}	S_{oi}	por.	air perm.	commments
14-14-48-3 W5	52.8 62.8	21.3 20.4	19.0 16.2	92. 7.7	
Average	46.7	24.7	16.7	n/c	
Range	25.0 to 65.0	15.0 to 42.0	13.0 to 22.0	379. to 0.14	

Appendix 2

Sample Computer Output, Case One.

55

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L'sting of 372OUT at 02:52:52 on FEB  5, 1988 for CCid=BEHR on UALTAMTS                                          Page    1

     ***********************************************************************************
                                    S W A N F L O W - 2 D
                   SIMULTANEOUS WATER, AIR, AND NAPL FLOW IN TWO DIMENSIONS
                                         WRITTEN BY:
                                      CHARLES R. FAUST
                                     JAMES G. RUMBAUGH
                                       GEOTRANS, INC.
                                    250 EXCHANGE PLACE
                                           SUITE A
                                        HERNDON, VA
     ***********************************************************************************

     LENS 10:1  GRADIENT = 0.02  EPSILON = 1000 ----STEADY STATE----
          DATE .... 02 FEB 1988                             RUN NO .... 7_2

          NUMBER OF BLOCKS IN THE X-DIRECTION (COLUMNS) =    60
          NUMBER OF BLOCKS IN THE Z-DIRECTION (LAYERS)  =    20
          MAXIMUM OF NEWTON-RAPHSON ITERATIONS          =     5
          MAXIMUM BANDWIDTH                             =     0
          MAXIMUM NUMBER OF TIME STEPS                  =    60
          NUMBER OF ACTIVE GRID BLOCKS                  =  1740
          NUMBER OF TIME STEPS BETWEEN PRINTOUTS        =    50
          PRINT NAPL AND WATER POTENTIALS? (1=YES)      =     1
          PRINT DETAILED KR TABLES?        (1=YES)      =     0
          WRITE A PLOT FILE?               (1=YES)      =     1
          NUMBER OF OBSERVATION BLOCKS                  =     0
          WRITE A RESTART FILE?            (1=YES)      =     1


          GRID BLOCK THICKNESS (DY)                         =   1.0000
          MASS BALANCE TOLERANCE FOR NEWTON-RAPHSON IT.     =  0.10000E-01
          INITIAL TIME VALUE                                =  0.00000E+00
          WATER DENSITY                                     =   1000.0
          NAPL DENSITY                                      =   1000.0
          WATER VISCOSITY                                   =  0.10000E-02
          NAPL VISCOSITY                                    =  0.20000E-02
          GRAVITATIONAL CONSTANT IN THE Z-DIRECTION         =  -9.8100
          GRAVITATIONAL CONSTANT IN THE X-DIRECTION         =  0.00000E+00


      ........................................................................................................
                                                    2 PC-KR TABLES WILL BE READ
      ........................................................................................................

                     *********** TABLE NUMBER    1 ***********

          NAPL-WATER CAP.       WATER          RELATIVE PERM.    RELATIVE PERM.
             PRESSURE         SATURATION           WATER             NAPL

          240000.00000         -0.05000           0.00000           1.00000
          240000.00000          0.00000           0.00000           1.00000
          240000.00000          0.05000           0.00000           1.00000
          240000.00000          0.10000           0.00000           1.00000
          240000.00000          0.15000           0.00000           1.00000
          240000.00000          0.20000           0.00000           1.00000
          240000.00000          0.25000           0.00000           1.00000
          240000.00000          0.30000           0.00000           1.00000
          150000.00000          0.35000           0.00000           1.00000
           60000.00000          0.40000           0.00000           1.00000
           45000.00000          0.45000           0.00000           1.00000
           30000.00000          0.50000           0.00500           0.50000
           21000.00000          0.55000           0.01200           0.25000
           15000.00000          0.60000           0.02800           0.12300
           13000.00000          0.65000           0.08700           0.06500
           11000.00000          0.70000           0.15200           0.02100
            9000.00000          0.75000           0.22700           0.00400
            7000.00000          0.80000           0.30000           0.00000
            6000.00000          0.85000           0.37500           0.00000
            5500.00000          0.90000           0.50000           0.00000
            5250.00000          0.95000           0.65000           0.00000
            5000.00000          1.00000           1.00000           0.00000
            5000.00000          1.05000           1.00000           0.00000

          AIR-NAPL SYSTEM -- PC-KR TABLE NUMBER    1
          NAPL KR AT RESIDUAL WATER SATURATION :    0.88000

           AIR-NAPL CAP.         AIR           RELATIVE PERM.    RELATIVE PERM.
             PRESSURE         SATURATION           NAPL              AIR

          -5500.00000           1.00000           0.00000           0.00000
              0.00000           0.00000           0.00000           0.00000

                     *********** TABLE NUMBER    2 ***********

          NAPL-WATER CAP.       WATER          RELATIVE PERM.    RELATIVE PERM.
             PRESSURE         SATURATION           WATER             NAPL

          480000.00000         -0.05000           0.00000           1.00000
          480000.00000          0.00000           0.00000           1.00000
          480000.00000          0.05000           0.00000           1.00000
          480000.00000          0.10000           0.00000           1.00000
          480000.00000          0.15000           0.00000           1.00000
          480000.00000          0.20000           0.00000           1.00000
          480000.00000          0.25000           0.00000           1.00000
          480000.00000          0.30000           0.00000           1.00000
          480000.00000          0.35000           0.00000           1.00000
          480000.00000          0.40000           0.00000           1.00000
          480000.00000          0.45000           0.00000           1.00000
          480000.00000          0.50000           0.00500           0.50000
          480000.00000          0.55000           0.01200           0.25000
          280000.00000          0.60000           0.02800           0.12300
          240000.00000          0.65000           0.08700           0.06500
          140000.00000          0.70000           0.15200           0.02100
          110000.00000          0.75000           0.22700           0.00400
           87500.00000          0.80000           0.30000           0.00000
           70000.00000          0.85000           0.37500           0.00000
           55000.00000          0.90000           0.50000           0.00000
           40000.00000          0.95000           0.65000           0.00000
           30000.00000          1.00000           1.00000           0.00000
          30000.00000          1.05000          1.00000          0.00000

          AIR-NAPL SYSTEM -- PC-KR TABLE NUMBER   2
          NAPL KR AT RESIDUAL WATER SATURATION :   0.68000

           AIR-NAPL CAP.          AIR         RELATIVE PERM.   RELATIVE PERM.
             PRESSURE          SATURATION         NAPL              AIR

           -5800.00000          1.00000         0.00000          0.00000
               0.00000          0.00000         0.00000          0.00000
 ------------------------------------------------------------------------------------------------------------------------

 ------------------------------------------------------------------------------------------------------------------------
                                                   2 PERMEABILITY SETS WILL BE READ
 ------------------------------------------------------------------------------------------------------------------------

 SET NUMBER     KX        KZ

      1 0.10000E-12 0.10000E-12
      2 0.10000E-15 0.10000E-15
 ------------------------------------------------------------------------------------------------------------------------
                                                   2 POROSITY SETS WILL BE READ
 ------------------------------------------------------------------------------------------------------------------------

 SET NUMBER      REF. POROSITY  COMPRESSIBILITY  REF. PRESSURE

      1          0.20000          0.10000E-08      0.10000E+06
      2          0.50000E-01      0.10000E-08      0.10000E+06
 ------------------------------------------------------------------------------------------------------------------------
                                                GRID BLOCK SPACINGS IN THE X-DIRECTION
 ------------------------------------------------------------------------------------------------------------------------

    5.0000       10.000       50.000       50.000       50.000       50.000       50.000       50.000       50.000       50.000
    25.000       20.000       10.000       10.000       5.0000       5.0000       5.0000       5.0000       5.0000       5.0000
    5.0000       5.0000       5.0000       10.000       10.000       10.000       15.000       15.000       15.000       25.000
    25.000       15.000       15.000       15.000       10.000       10.000       10.000       5.0000       5.0000       5.0000
    5.0000       5.0000       5.0000       5.0000       5.0000       5.0000       10.000       10.000       20.000       25.000
    50.000       50.000       50.000       50.000       50.000       50.000       50.000       50.000       10.000       5.0000
 ------------------------------------------------------------------------------------------------------------------------
                                                GRID BLOCK SPACINGS IN THE Z-DIRECTION
 ------------------------------------------------------------------------------------------------------------------------

    5.0000       25.000       25.000       25.000       25.000       12.500       5.0000       5.0000       5.0000       5.0000
    2.5000       2.5000       2.5000       2.5000       2.5000       2.5000       2.5000       2.5000       2.5000       2.5000
    5.0000       5.0000       5.0000       5.0000       12.500       25.000       25.000       25.000       25.000       5.0000
 ------------------------------------------------------------------------------------------------------------------------
                                                THERE ARE    2 PROPERTY COMBINATION SETS
 ------------------------------------------------------------------------------------------------------------------------

    SET NUMBER     PC-KR TABLE   K CLASS   POROSITY CLASS

          1             1           1             1
          2             2           2             2
 ------------------------------------------------------------------------------------------------------------------------
                                                GRID BLOCK NUMBERS
 ------------------------------------------------------------------------------------------------------------------------

                          X-DIRECTION  ---->

 LAYER   1    -1   1  31  61  91 121 151 181 211 241 271 301 331 361 391 421 451 481 511 541 571 601 631 661 691
              721 751 781 811 841 871 901 931 961 991102110511081111111411171120112311261129113211351138114111441
             147115011531156115911621165116811711  -1
 LAYER   2    -1   2  32  62  92 122 152 182 212 242 272 302 332 362 392 422 452 482 512 542 572 602 632 662 692
              722 752 782 812 842 872 902 932 962 992102210521082111211421172120212321262129213221352138214121442
             147215021532156215921622165216821712  -1
 LAYER   3    -1   3  33  63  93 123 153 183 213 243 273 303 333 363 393 423 453 483 513 543 573 603 633 663 693
              723 753 783 813 843 873 903 933 963 993102310531083111311431173120312331263129313231353138314131443
             147315031533156315931623165316831713  -1
 LAYER   4    -1   4  34  64  94 124 154 184 214 244 274 304 334 364 394 424 454 484 514 544 574 604 634 664 694
              724 754 784 814 844 874 904 934 964 994102410541084111411441174120412341264129413241354138414141444
             147415041534156415941624165416841714  -1
 LAYER   5    -1   5  35  65  95 125 155 185 215 245 275 305 335 365 395 425 455 485 515 545 575 605 635 665 695
              725 755 785 815 845 875 905 935 965 995102510551085111511451175120512351265129513251355138514151445
             147515051535156515951625165516851715  -1
 LAYER   6    -1   6  36  66  96 126 156 186 216 246 276 306 336 366 396 426 456 486 516 546 576 606 636 666 696
              726 756 786 816 846 876 906 936 966 996102610561086111611461176120612361266129613261356138614161446
             147615061536156615961626165616861716  -1
 LAYER   7    -1   7  37  67  97 127 157 187 217 247 277 307 337 367 397 427 457 487 517 547 577 607 637 667 697
              727 757 787 817 847 877 907 937 967 997102710571087111711471177120712371267129713271357138714171447
             147715071537156715971627165716871717  -1
 LAYER   8    -1   8  38  68  98 128 158 188 218 248 278 308 338 368 398 428 458 488 518 548 578 608 638 668 698
              728 758 788 818 848 878 908 938 968 998102810581088111811481178120812381268129813281358138814181448
             147815081538156815981628165816881718  -1
 LAYER   9    -1   9  39  69  99 129 159 189 219 249 279 309 339 369 399 429 459 489 519 549 579 609 639 669 699
              729 759 789 819 849 879 909 939 969 999102910591089111911491179120912391269129913291359138914191449
             147915091539156915991629165916891719  -1
 LAYER  10    -1  10  40  70 100 130 160 190 220 250 280 310 340 370 400 430 460 490 520 550 580 610 640 670 700
              730 760 790 820 850 880 910 940 9701000103010601090112011501180121012401270130013301360139014201450
             148015101540157016001630166016901720  -1
 LAYER  11    -1  11  41  71 101 131 161 191 221 251 281 311 341 371 401 431 461 491 521 551 581 611 641 671 701
              731 761 791 821 851 881 911 941 9711001103110611091112111511181121112411271130113311361139114211451
             148115111541157116011631166116911721  -1
 LAYER  12    -1  12  42  72 102 132 162 192 222 252 282 312 342 372 402 432 462 492 522 552 582 612 642 672 702
              732 762 792 822 852 882 912 942 9721002103210621092112211521182121212421272130213321362139214221452
             148215121542157216021632166216921722  -1
 LAYER  13    -1  13  43  73 103 133 163 193 223 253 283 313 343 373 403 433 463 493 523 553 583 613 643 673 703
              733 763 793 823 853 883 913 943 9731003103310631093112311531183121312431273130313331363139314231453
             148315131543157316031633166316931723  -1
 LAYER  14    -1  14  44  74 104 134 164 194 224 254 284 314 344 374 404 434 464 494 524 554 584 614 644 674 704
              734 764 794 824 854 884 914 944 9741004103410641094112411541184121412441274130413341364139414241454
             148415141544157416041634166416941724  -1
 LAYER  15    -1  15  45  75 105 135 165 195 225 255 285 315 345 375 405 435 465 495 525 555 585 615 645 675 705
              735 765 795 825 855 885 915 945 9751005103510651095112511551185121512451275130513351365139514251455
             148515151545157516051635166516951725  -1
 LAYER  16    -1  16  46  76 106 136 166 196 226 256 286 316 346 376 406 436 466 496 526 556 586 616 646 676 706
              736 766 796 826 856 886 916 946 9761006103610661096112611561186121612461276130613361366139614261456
             148615161546157616061636166616961726  -1
 LAYER  17    -1  17  47  77 107 137 167 197 227 257 287 317 347 377 407 437 467 497 527 557 587 617 647 677 707
              737 767 797 827 857 887 917 947 9771007103710671097112711571187121712471277130713371367139714271457
             148715171547157716071637166716971727  -1
 LAYER  18    -1  18  48  78 108 138 168 198 228 258 288 318 348 378 408 438 468 498 528 558 588 618 648 678 708
              738 768 798 828 858 888 918 948 9781008103810681098112811581188121812481278130813381368139814281458
             148815181548157816081638166816981728  -1
 LAYER  19    -1  19  49  79 109 139 169 199 229 259 289 319 349 379 409 439 469 499 529 559 589 619 649 679 709
              739 769 799 829 859 889 919 949 9791009103910691099112911591189121912491279130913391369139914291459
             148915191549157916091639166916991729  -1
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Listing of E720UT at 02:52:52 on FEB  5, 1988 for CCid=BENR on UALTAMTS                                        Page    3
LAYER  20    -1  20  50  80 110 140 170 200 230 260 290 320 350 380 410 440 470 500 530 560 590 620 650 680 710
            740 770 800 830 860 890 920 950 9801010104010701100113011601190122012501280131013401370140014301460
           149015201550158016101640167017001730  -1
LAYER  21    -1  21  51  81 111 141 171 201 231 261 291 321 351 381 411 441 471 501 531 561 591 621 651 681 711
            741 771 801 831 861 891 921 951 9811011104110711101113111611191122112511281131113411371140114311461
           149115211551158116111641167117011731  -1
LAYER  22    -1  22  52  82 112 142 172 202 232 262 292 322 352 382 412 442 472 502 532 562 592 622 652 682 712
            742 772 802 832 862 892 922 952 9821012104210721102113211621192122212521282131213421372140214321462
           149215221552158216121642167217021732  -1
LAYER  23    -1  23  53  83 113 143 173 203 233 263 293 323 353 383 413 443 473 503 533 563 593 623 653 683 713
            743 773 803 833 863 893 923 953 9831013104310731103113311631193122312531283131313431373140314331463
           149315231553158316131643167317031733  -1
LAYER  24    -1  24  54  84 114 144 174 204 234 264 294 324 354 384 414 444 474 504 534 564 594 624 654 684 714
            744 774 804 834 864 894 924 954 9841014104410741104113411641194122412541284131413441374140414341464
           149415241554158416141644167417041734  -1
LAYER  25    -1  25  55  85 115 145 175 205 235 265 295 325 355 385 415 445 475 505 535 565 595 625 655 685 715
            745 775 805 835 865 895 925 955 9851015104510751105113511651195122512551285131513451375140514351465
           149515251555158516151645167517051735  -1
LAYER  26    -1  26  56  86 116 146 176 206 236 266 296 326 356 386 416 446 476 506 536 566 596 626 656 686 716
            746 776 806 836 866 896 926 956 9861016104610761106113611661196122612561286131613461376140614361466
           149615261556158616161646167617061736  -1
LAYER  27    -1  27  57  87 117 147 177 207 237 267 297 327 357 387 417 447 477 507 537 567 597 627 657 687 717
            747 777 807 837 867 897 927 957 9871017104710771107113711671197122712571287131713471377140714371467
           149715271557158716171647167717071737  -1
LAYER  28    -1  28  58  88 118 148 178 208 238 268 298 328 358 388 418 448 478 508 538 568 598 628 658 688 718
            748 778 808 838 868 898 928 958 9881018104810781108113811681198122812581288131813481378140814381468
           149815281558158816181648167817081738  -1
LAYER  29    -1  29  59  89 119 149 179 209 239 269 299 329 359 389 419 449 479 509 539 569 599 629 659 689 719
            749 779 809 839 869 899 929 959 9891019104910791109113911691199122912591289131913491379140914391469
           149915291559158916191649167917091739  -1
LAYER  30    -1  30  60  90 120 150 180 210 240 270 300 330 360 390 420 450 480 510 540 570 600 630 660 690 720
            750 780 810 840 870 900 930 960 9901020105010801110114011701200123012601290132013501380141014401470
           150015301560159016201650168017101740  -1

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                                          PROPERTY CLASS NUMBERS
.................................................................................................................

                     X-DIRECTION  --  I INDEX
              1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25
             26  27  28  29  30  31  32  33  34  35  36  37  38  39  40  41  42  43  44  45  46  47  48  49  50
             51  52  53  54  55  56  57  58  59  60
LAYER   1     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER   2     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER   3     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER   4     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER   5     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER   6     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER   7     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER   8     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER   9     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  10     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  11     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   1   1   1   1   1   1   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  12     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   1
              1   1   1   1   1   1   1   1   1   1   1   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  13     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   1   1   1   1
              1   1   1   1   1   1   1   1   1   1   1   1   1   1   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  14     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   1   1   1   1   1   1
              1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  15     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   1   1   1   1   1   1   1
              1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  16     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   1   1   1   1   1   1   1
              1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  17     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   1   1   1   1   1   1
              1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  18     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   1   1   1   1
              1   1   1   1   1   1   1   1   1   1   1   1   1   1   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  19     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   1
              1   1   1   1   1   1   1   1   1   1   1   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  20     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   1   1   1   1   1   1   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  21     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  22     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  23     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  24     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  25     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  26     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  27     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  28     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
```

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                                                                                                       Page    4
Listing of 572OUT at 02:52:52 on FEB  5, 1988 for CCid=BEHR on UALTAMTS
                                                                2  2  2  2  2  2  2  2  2  2  2  2  2  2
               2  2  2  2  2  2  2  2  2  2
               2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
   LAYER  29   2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
               2  2  2  2  2  2  2  2  2  2
               2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
   LAYER  30   2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
               2  2  2  2  2  2  2  2  2  2
               2  2  2  2  2  2  2  2  2  2

 ********** CALCULATED MAXIMUM BANDWIDTH =  123 **********
 ................................................................................................
 ......................................INITIAL CONDITION DATA....................................
 ................................................................................................
 ................................................................................................
 ......................................INITIAL NAPL PRESSURES....................................
 ................................................................................................

  LAYER    1
   [illegible]
  LAYER    2
   [illegible]
  LAYER    3
   [illegible]
  LAYER    4
   [illegible]
  LAYER    5
   [illegible]
  LAYER    6
   [illegible]
  LAYER    7
   [illegible]
  LAYER    8
   [illegible]
  LAYER    9
   [illegible]
  LAYER   10
   [illegible]
  LAYER   11
   [illegible]
  LAYER   12
   [illegible]
  LAYER   13
   [illegible]
  LAYER   14
   [illegible]
  LAYER   15
   [illegible]
```

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Listing of S72OUT at 02:52:52 on FEB  5, 1988 for CCid=BEHR on UALTAMTS                          Page    5
 497         LAYER  16
 498          [illegible]
 499          [illegible]
 500          [illegible]
 501          [illegible]
 502          [illegible]
 503          [illegible]
 504         LAYER  17
 505          [illegible]
 506          [illegible]
 507          [illegible]
 508          [illegible]
 509          [illegible]
 510          [illegible]
 511         LAYER  18
 512          [illegible]
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 514          [illegible]
 515          [illegible]
 516          [illegible]
 517          [illegible]
 518         LAYER  19
 519          [illegible]
 520          [illegible]
 521          [illegible]
 522          [illegible]
 523          [illegible]
 524          [illegible]
 525         LAYER  20
 526          [illegible]
 527          [illegible]
 528          [illegible]
 529          [illegible]
 530          [illegible]
 531          [illegible]
 532         LAYER  21
 533          [illegible]
 534          [illegible]
 535          [illegible]
 536          [illegible]
 537          [illegible]
 538          [illegible]
 539         LAYER  22
 540          [illegible]
 541          [illegible]
 542          [illegible]
 543          [illegible]
 544          [illegible]
 545          [illegible]
 546         LAYER  23
 547          [illegible]
 548          [illegible]
 549          [illegible]
 550          [illegible]
 551          [illegible]
 552          [illegible]
 553         LAYER  24
 554          [illegible]
 555          [illegible]
 556          [illegible]
 557          [illegible]
 558          [illegible]
 559          [illegible]
 560         LAYER  25
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 564          [illegible]
 565          [illegible]
 566          [illegible]
 567         LAYER  26
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 570          [illegible]
 571          [illegible]
 572          [illegible]
 573          [illegible]
 574         LAYER  27
 575          [illegible]
 576          [illegible]
 577          [illegible]
 578          [illegible]
 579          [illegible]
 580          [illegible]
 581         LAYER  28
 582          [illegible]
 583          [illegible]
 584          [illegible]
 585          [illegible]
 586          [illegible]
 587          [illegible]
 588         LAYER  29
 589          [illegible]
 590          [illegible]
 591          [illegible]
 592          [illegible]
 593          [illegible]
 594          [illegible]
 595         LAYER  30
 596          [illegible]
 597          [illegible]
 598          [illegible]
 599          [illegible]
 600          [illegible]
 601          [illegible]
 602         ...........................................................................................
 603                                        INITIAL WATER SATURATIONS
 604         ...........................................................................................
 605
 606         LAYER   1
 607           1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
 608           1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
 609           1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
 610           1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
 611           1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
 612           1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
 613         LAYER   2
 614           1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
 615           1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
 616           1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
 617           1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
 618           1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
 619           1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
 620         LAYER   3
```

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Listing of S72OUT at 02:52:52 on FEB  6, 1988 for CCid=BENR on UALTAMTS                                    Page    6
   621        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   622        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   623        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   624        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   625        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   626        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   627     LAYER    4
   628        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   629        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   630        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   631        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   632        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   633        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   634     LAYER    5
   635        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   636        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   637        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   638        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   639        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   640        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   641     LAYER    6
   642        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   643        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   644        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   645        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   646        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   647        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   648     LAYER    7
   649        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   650        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   651        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   652        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   653        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   654        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   655     LAYER    8
   656        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   657        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   658        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   659        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   660        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   661        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   662     LAYER    9
   663        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   664        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   665        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   666        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   667        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   668        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   669     LAYER   10
   670        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   671        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   672        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   673        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   674        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   675        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   676     LAYER   11
   677        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   678        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   679        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   680        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   681        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   682        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   683     LAYER   12
   684        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   685        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   686        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   687        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   688        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   689        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   690     LAYER   13
   691        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   692        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   693        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   694        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   695        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   696        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   697     LAYER   14
   698        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   699        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   700        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   701        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   702        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   703        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   704     LAYER   15
   705        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   706        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   707        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   708        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   709        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   710        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   711     LAYER   16
   712        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   713        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   714        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   715        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   716        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   717        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   718     LAYER   17
   719        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   720        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   721        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   722        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   723        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   724        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   725     LAYER   18
   726        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   727        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   728        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   729        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   730        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   731        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   732     LAYER   19
   733        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   734        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   735        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   736        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   737        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   738        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   739     LAYER   20
   740        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   741        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   742        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   743        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
   744        1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
```

```
Listing of S72OUT at 02:52:52 on FEB  5, 1988 for CCid=BENR on UALTAMTS                                   Page    7
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
    LAYER  21
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
    LAYER  22
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
    LAYER  23
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
    LAYER  24
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
    LAYER  25
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
    LAYER  26
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
    LAYER  27
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
    LAYER  28
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
    LAYER  29
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
    LAYER  30
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
      1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
 ..........................................................................................................
                                          RECURRENT DATA SET
 ..........................................................................................................

      INITIAL TIME STEP SIZE =  0.86400E+06
      MINIMUM TIME STEP SIZE =    3600.0
      MAXIMUM WATER SATURATION CHANGE =  0.10000
      TIME STEP MULTIPLIER =      1.2500
      TIME TO READ NEW RECURRENT DATA =  0.10000E+17
      NUMBER OF SOURCE/SINK BLOCKS =     0
      CODE FOR CHANGING FLUX RATES =     0

 ..........................................................................................................
 ..........................................................................................................
                          TIME STEP NUMBER =    1          TIME VALUE =  0.86400E+06
 ..........................................................................................................

                      WATER BALANCE          NAPL BALANCE
                                              0.00000E+00
      CONSTANT PRES     2.7694                0.00000E+00
      SOURCE/SINKS      0.00000E+00           0.00000E+00
      STORAGE          -2.7694                0.00000E+00
      PER CENT ERROR    0.34251E-06

         STEP NUMBER    1 COMPLETED          SIMULATION TIME IN SECONDS 0.864E+06
         *************************                           IN MINUTES 0.144E+05
                                                             IN HOURS    240.
                                                             IN DAYS     10.00
                                                             IN YEARS   0.274E-01
 ..........................................................................................................
                          TIME STEP NUMBER =    2          TIME VALUE =  0.19440E+07
 ..........................................................................................................

                      WATER BALANCE          NAPL BALANCE
                                              0.00000E+00
      CONSTANT PRES     2.7672                0.00000E+00
      SOURCE/SINKS      0.00000E+00           0.00000E+00
      STORAGE          -2.7672                0.00000E+00
      PER CENT ERROR   -0.77121E-07

         STEP NUMBER    2 COMPLETED          SIMULATION TIME IN SECONDS 0.194E+07
         *************************                           IN MINUTES 0.324E+05
                                                             IN HOURS    540.
                                                             IN DAYS     22.5
                                                             IN YEARS   0.616E-01
 ..........................................................................................................
                          TIME STEP NUMBER =    3          TIME VALUE =  0.32940E+07
 ..........................................................................................................

                      WATER BALANCE          NAPL BALANCE
                                              0.00000E+00
      CONSTANT PRES     2.7275                0.00000E+00
      SOURCE/SINKS      0.00000E+00
    LAYER  20
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  21
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  22
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  23
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  24
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  25
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  26
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  27
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  28
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  29
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  30
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
      1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
 ........................................................................................................
                                            NAPL SATURATIONS
 ........................................................................................................

    LAYER   1
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    LAYER   2
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    LAYER   3
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    LAYER   4
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    LAYER   5
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
     0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
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    LAYER   7
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 LAYER   24
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LAYER  26
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LAYER  27
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LAYER  28
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LAYER  29
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LAYER  30
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                                               NAPL POTENTIALS
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LAYER    1
    603.06       603.23      603.91      605.04      606.17      607.20      608.43      609.56      610.65      611.78
    612.57       613.03      613.32      613.51      613.65      613.73      613.82      613.91      613.98      614.07
    614.15       614.23      614.31      614.42      614.56      614.70      614.86      615.04      615.21      615.43
    615.85       615.91      615.96      616.26      616.42      616.55      616.69      616.81      616.88      616.96
    617.04       617.12      617.21      617.29      617.36      617.47      617.61      617.80      618.09      618.54
    619.34       620.44      621.56      622.69      623.82      624.95      626.08      627.21      627.89      628.08
LAYER    2
    603.06       603.23      603.91      605.04      606.17      607.20      608.43      609.56      610.65      611.78
    612.56       613.03      613.32      613.51      613.65      613.74      613.83      613.91      614.00      614.08
    614.16       614.24      614.32      614.43      614.57      614.70      614.85      615.04      615.21      615.43
    615.85       615.90      615.97      616.25      616.41      616.55      616.69      616.80      616.86      616.96
    617.04       617.12      617.20      617.29      617.36      617.47      617.60      617.79      618.06      618.54
    619.34       620.44      621.56      622.69      623.82      624.95      626.08      627.21      627.89      628.08
LAYER    3
    603.06       603.23      603.91      605.04      606.17      607.20      608.43      609.56      610.65      611.79
    612.60       613.07      613.37      613.56      613.70      613.75      613.86      613.97      614.05      614.16
    614.22       614.30      614.37      614.48      614.62      614.75      614.91      615.08      615.24      615.46
    615.86       615.88      616.04      616.21      616.36      616.48      616.63      616.74      616.82      616.90
    616.96       617.05      617.15      617.24      617.33      617.42      617.58      617.75      618.05      618.52
    619.32       620.44      621.56      622.69      623.82      624.95      626.08      627.21      627.89      628.06
LAYER    4
    603.06       603.23      603.91      605.04      606.17      607.20      608.43      609.56      610.89      611.81
    612.65       613.13      613.45      613.65      613.80      613.89      613.98      614.07      614.19      614.25
    614.33       614.41      614.46      614.59      614.73      614.85      614.99      615.14      615.28      615.48
    615.56       615.83      615.97      616.12      616.27      616.29      616.52      616.63      616.71      616.79
    616.67       616.95      617.04      617.13      617.22      617.32      617.47      617.67      617.88      618.47
    619.30       620.43      621.56      622.69      623.82      624.95      626.08      627.21      627.89      628.08
LAYER    5
    603.06       603.23      603.91      605.04      606.17      607.20      608.43      609.56      610.70      611.84
    612.70       613.22      613.56      613.78      613.95      614.05      614.15      614.26      614.34      614.43
    614.52       614.60      614.67      614.76      614.90      615.01      615.13      615.25      615.36      615.48
    615.53       615.76      615.87      615.98      616.11      616.22      616.36      616.44      616.53      616.60
    616.55       616.77      616.87      616.96      617.07      617.17      617.33      617.55      617.69      618.41
    619.28       620.42      621.56      622.69      623.82      624.95      626.08      627.21      627.89      628.06
LAYER    6
    603.06       603.23      603.91      605.04      606.17      607.20      608.43      609.57      610.70      611.86
    612.75       613.30      613.67      613.92      614.11      614.23      614.35      614.46      614.56      614.66
    614.75       614.83      614.90      615.00      615.10      615.19      615.28      615.38      615.42      615.51
    615.81       615.89      615.76      615.84      615.93      616.01      616.12      616.21      616.29      616.27
    616.46       616.55      616.65      616.77      616.89      617.01      617.19      617.44      617.62      618.27
    619.26       620.41      621.56      622.66      623.82      624.95      626.08      627.21      627.89      628.06
LAYER    7
    603.06       603.23      603.91      605.04      606.17      607.20      608.43      609.57      610.71      611.86
    612.76       613.33      613.72      613.99      614.19      614.33      614.46      614.56      614.70      614.80
    614.86       614.97      615.04      615.13      615.22      615.29      615.35      615.42      615.47      615.53
    615.56       615.65      615.70      615.75      615.83      615.90      615.99      616.07      616.14      616.22
    616.31       616.42      616.53      616.65      616.79      616.92      617.12      617.38      617.70      618.35
    619.26       620.41      621.56      622.68      623.82      624.95      626.08      627.21      627.80      628.06
LAYER    8
    603.06       603.23      603.91      605.04      606.17      607.20      608.43      609.57      610.71      611.87
    612.77       613.34      613.75      614.03      614.25      614.39      614.53      614.66      614.76      614.90
    614.99       615.07      615.13      615.21      615.28      615.35      615.40      615.45      615.49      615.53
    615.58       615.62      615.66      615.72      615.77      615.83      615.91      615.98      616.06      616.13
    616.22       616.33      616.45      616.59      616.73      616.87      617.09      617.37      617.77      618.34
    619.26       620.41      621.56      622.66      623.82      624.95      626.08      627.21      627.88      628.06
LAYER    9
    603.06       603.23      603.91      605.04      606.17      607.20      608.43      609.57      610.71      611.87
    612.78       613.35      613.76      614.07      614.30      614.45      614.61      614.76      614.89      615.01
    615.16       615.17      615.22      615.30      615.37      615.41      615.45      615.49      615.52      615.54
    615.57       615.60      615.63      615.67      615.71      615.75      615.82      615.86      615.94      616.02
    616.11       616.23      616.36      616.51      616.66      616.82      617.05      617.34      617.75      618.34
    619.25       620.41      621.56      622.66      623.82      624.95      626.08      627.21      627.89      628.09
LAYER   10
    603.06       603.23      603.91      605.04      606.17      607.20      608.43      609.57      610.71      611.87
    612.79       613.37      613.80      614.10      614.35      614.52      614.69      614.86      615.01      615.14
    615.22       615.30      615.34      615.38      615.45      615.48      615.50      615.53      615.54      615.55
    615.57       615.58      615.59      615.62      615.64      615.67      615.72      615.77      615.82      615.88
    615.96       616.10      616.26      616.43      616.60      616.77      617.02      617.32      617.75      618.33
    619.25       620.41      621.56      622.66      623.82      624.95      626.08      627.21      627.89      628.06
LAYER   11
    603.06       603.23      603.91      605.04      606.17      607.20      608.43      609.57      610.71      611.87
    612.79       613.38      613.81      614.12      614.38      614.56      614.75      614.95      615.13      615.28
    615.34       615.41      615.44      615.47      615.52      615.53      615.53      613.00      613.00      613.01
    613.01       613.02      613.03      615.56      615.59      615.60      615.65      615.66      615.71      615.77
    615.86       615.90      616.17      616.36      616.55      616.74      617.00      617.31      617.74      618.33
    619.24       620.41      621.56      622.66      623.82      624.95      626.08      627.21      627.89      628.08
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Listing of S72OUT at 02:52:52 on FEB  5, 1988 for CCid=BENR on UALTAMTS                                Page   21

2481     LAYER  12
2482      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.57    610.71    611.87
2483      612.79    613.38    613.82    614.13    614.60    614.59    614.80    615.02    615.22    615.39
2484      615.42    615.48    615.50    615.52    612.99    613.00    613.00    613.00    613.00    613.01
2485      613.01    613.02    613.02    613.02    613.02    613.03    615.80    615.51    615.63    615.59
2486      615.78    615.80    616.16    615.32    615.53    616.72    615.98    617.30    617.74    616.33
2487      619.24    620.41    621.55    622.66    623.82    624.95    626.08    627.21    627.89    628.05
2488     LAYER  13
2489      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.57    610.71    611.87
2490      612.79    613.38    613.82    614.14    614.41    614.61    614.84    615.08    615.32    615.47
2491      615.50    612.99    612.99    612.99    612.99    613.00    613.00    613.00    613.00    613.01
2492      613.01    613.02    613.02    613.02    613.02    613.03    613.03    613.03    613.03    615.82
2493      615.55    615.79    616.03    615.28    616.50    616.70    616.88    617.28    617.73    616.32
2494      619.24    620.41    621.55    622.66    623.82    624.95    626.08    627.21    627.89    628.05
2495     LAYER  14
2496      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.57    610.71    611.87
2497      612.79    613.21    613.83    614.15    614.43    614.63    614.87    615.16    615.45    612.98
2498      612.99    612.99    612.99    612.99    612.99    613.00    613.00    613.00    613.00    613.01
2499      613.01    613.02    613.02    613.02    613.02    613.03    613.02    613.02    613.03    613.03
2500      613.03    615.66    615.96    615.25    616.46    616.59    616.57    617.28    617.73    616.33
2501      619.24    620.41    621.55    622.66    623.82    624.95    626.08    627.21    627.88    628.05
2502     LAYER  15
2503      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.57    610.71    611.87
2504      612.79    613.38    613.83    614.15    614.43    614.64    614.88    615.23    612.98    612.98
2505      612.99    612.99    612.99    612.99    612.99    613.00    613.00    613.00    613.00    613.01
2506      613.01    613.02    613.02    613.02    613.02    613.03    613.03    613.03    613.03    613.03
2507      613.03    613.03    615.89    616.22    616.47    616.59    616.57    617.29    617.73    616.32
2508      619.24    620.41    621.55    622.66    623.82    624.95    626.08    627.21    627.88    628.06
2509     LAYER  16
2510      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.57    610.71    611.87
2511      612.79    613.39    613.83    614.15    614.43    614.64    614.88    615.22    612.98    612.98
2512      612.99    612.99    612.99    612.99    612.99    613.00    613.00    613.00    613.00    613.01
2513      613.01    613.02    613.02    613.02    613.02    613.03    613.03    613.03    613.03    613.03
2514      613.03    613.03    615.89    616.22    616.47    616.59    616.57    617.29    617.73    616.32
2515      619.24    620.41    621.55    622.66    623.82    624.95    626.08    627.21    627.88    628.06
2516     LAYER  17
2517      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.57    610.71    611.87
2518      612.79    613.38    613.83    614.15    614.43    614.63    614.87    615.16    615.45    612.99
2519      612.99    612.99    612.99    612.99    612.99    613.00    613.00    613.00    613.00    613.01
2520      613.01    613.02    613.02    613.02    613.02    613.03    613.02    613.03    613.03    613.03
2521      613.03    615.66    615.96    616.25    616.46    616.59    616.57    617.28    617.73    616.32
2522      619.24    620.41    621.55    622.66    623.82    624.95    626.08    627.21    627.88    628.06
2523     LAYER  18
2524      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.57    610.71    611.87
2525      612.79    613.38    613.82    614.14    614.41    614.61    614.84    615.08    615.32    615.47
2526      615.50    612.99    612.99    612.99    612.99    613.00    613.00    613.00    613.00    613.01
2527      613.01    613.02    613.02    613.02    613.02    613.02    613.03    613.03    613.03    615.82
2528      615.55    615.79    616.03    615.28    616.50    616.70    616.88    617.28    617.73    616.32
2529      619.24    620.41    621.55    622.66    623.82    624.95    626.08    627.21    627.88    628.06
2530     LAYER  19
2531      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.57    610.71    611.87
2532      612.79    613.38    613.82    614.13    614.40    614.59    614.80    615.02    615.22    615.39
2533      615.42    615.48    615.50    615.52    612.99    613.00    613.00    613.00    613.00    613.01
2534      613.01    613.02    613.02    613.02    613.02    613.03    615.80    615.61    615.63    615.59
2535      615.78    615.80    616.10    615.32    615.53    616.72    615.98    617.30    617.74    616.33
2536      619.24    620.41    621.55    622.66    623.82    624.95    626.08    627.21    627.89    628.06
2537     LAYER  20
2538      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.57    610.71    611.87
2539      612.79    613.38    613.81    614.12    614.38    614.56    614.75    614.99    615.13    615.26
2540      615.24    616.41    615.44    615.47    615.52    615.53    615.53    613.00    613.00    613.01
2541      613.01    613.02    613.02    615.58    615.59    615.60    615.65    615.68    615.71    615.77
2542      615.86    615.99    616.17    616.38    616.55    616.74    617.00    617.21    617.74    616.33
2543      619.24    620.41    621.55    622.66    623.82    624.95    626.08    627.21    627.88    628.06
2544     LAYER  21
2545      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.57    610.71    611.87
2546      612.79    613.37    613.80    614.10    614.35    614.52    614.69    614.86    615.01    615.14
2547      615.23    615.30    615.34    615.39    615.45    615.48    615.50    615.53    615.54    615.55
2548      615.57    615.56    615.55    615.52    615.54    615.57    615.72    615.77    615.83    615.89
2549      615.98    616.10    616.25    616.43    616.60    616.77    617.02    617.22    617.76    616.33
2550      619.25    620.41    621.55    622.66    623.82    624.95    626.08    627.21    627.88    628.06
2551     LAYER  22
2552      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.57    610.71    611.87
2553      612.78    613.36    613.74    614.07    614.30    614.45    614.61    614.78    614.88    615.01
2554      615.10    615.17    615.23    615.30    615.37    615.41    615.45    615.48    615.52    615.54
2555      615.67    615.60    615.63    615.67    615.71    615.75    615.82    615.86    615.94    616.03
2556      616.11    616.23    616.36    616.51    616.66    616.82    617.05    617.34    617.75    616.34
2557      619.25    620.41    621.55    622.66    623.82    624.95    626.08    627.21    627.89    628.06
2558     LAYER  23
2559      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.57    610.71    611.87
2560      612.77    613.34    613.75    614.03    614.28    614.39    614.53    614.66    614.79    614.90
2561      614.99    615.07    615.13    615.21    615.28    615.35    615.40    615.46    615.50    615.53
2562      615.58    615.62    615.66    615.72    615.77    615.82    615.91    615.99    616.05    616.13
2563      616.22    616.33    616.45    616.58    616.73    616.87    617.08    617.37    617.77    616.34
2564      619.25    620.41    621.55    622.66    623.82    624.95    626.08    627.21    627.88    628.06
2565     LAYER  24
2566      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.57    610.71    611.88
2567      612.76    613.33    613.72    613.99    614.15    614.33    614.46    614.58    614.70    614.80
2568      614.89    614.97    615.04    615.13    615.22    615.29    615.35    615.42    615.47    615.53
2569      615.58    615.66    615.70    615.76    615.82    615.90    615.99    616.07    616.14    616.22
2570      616.31    616.42    616.53    616.65    616.79    616.92    617.12    617.39    617.78    616.35
2571      619.25    620.41    621.55    622.66    623.82    624.95    626.08    627.21    627.88    628.06
2572     LAYER  25
2573      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.57    610.70    611.88
2574      612.75    613.30    613.67    613.92    614.11    614.23    614.35    614.48    614.58    614.66
2575      614.78    614.83    614.90    615.00    615.10    615.19    615.26    615.38    615.43    615.51
2576      615.61    615.69    615.78    615.84    615.93    616.01    616.12    616.21    616.30    616.37
2577      616.40    616.55    616.68    616.77    616.89    617.01    617.19    617.44    617.82    616.37
2578      619.26    620.41    621.55    622.66    623.82    624.95    626.08    627.21    627.89    628.06
2579     LAYER  26
2580      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.56    610.70    611.84
2581      612.70    613.22    613.56    613.78    613.95    614.05    614.15    614.26    614.34    614.43
2582      614.52    614.60    614.67    614.78    614.90    615.01    615.13    615.25    615.35    615.46
2583      615.63    615.78    615.87    615.98    616.11    616.22    616.34    616.44    616.53    616.60
2584      616.66    616.77    616.87    616.96    617.07    617.17    617.33    617.55    617.88    616.41
2585      619.26    620.42    621.55    622.69    623.83    624.95    626.06    627.21    627.88    628.06
2586     LAYER  27
2587      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.56    610.69    611.81
2588      612.55    613.13    613.45    613.65    613.80    613.89    613.98    614.07    614.16    614.25
2589      614.23    614.41    614.46    614.59    614.72    614.85    614.99    615.14    615.28    615.46
2590      615.66    615.83    615.97    616.12    616.27    616.39    616.52    616.63    616.71    616.78
2591      616.87    616.95    617.04    617.13    617.23    617.33    617.47    617.67    617.96    616.47
2592      619.30    620.43    621.56    622.69    623.83    624.95    626.08    627.21    627.88    628.06
2593     LAYER  28
2594      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.56    610.68    611.79
2595      612.50    613.07    613.37    613.55    613.70    613.78    613.86    613.97    614.06    614.14
2596      614.22    614.30    614.37    614.46    614.62    614.75    614.91    615.06    615.24    615.44
2597      615.68    615.86    616.04    616.21    616.36    616.49    616.62    616.74    616.83    616.90
2598      616.98    617.06    617.15    617.24    617.32    617.42    617.58    617.76    618.06    616.52
2599      619.32    620.44    621.58    622.69    623.82    624.95    626.08    627.21    627.88    628.06
2600     LAYER  29
2601      603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.56    610.68    611.78
2602      612.38    613.02    613.32    613.51    613.65    613.74    613.83    613.91    614.00    614.06
2603      614.18    614.24    614.32    614.43    614.57    614.70    614.86    615.04    615.21    615.43
2604      615.63    615.90    616.07    616.25    616.41    616.55    616.68    616.80    616.88    616.98
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Listing of 872OUT at 02:52:52 on FEB  5, 1988 for CCid=BEWR on UALTAMTS                              Page   22
       617.04    617.12    617.20    617.29    617.38    617.47    617.60    617.79    618.08    618.54
       619.34    620.44    621.56    622.69    623.82    624.95    626.08    627.21    627.89    628.06
     LAYER  30
       603.06    603.23    603.91    605.04    606.17    607.30    608.43    609.56    610.68    611.76
       612.57    613.02    613.32    613.51    613.65    613.73    613.82    613.91    613.99    614.07
       614.15    614.23    614.31    614.42    614.56    614.70    614.88    615.04    615.21    615.43
       615.69    615.91    616.04    616.26    616.42    616.55    616.69    616.81    616.88    616.96
       617.04    617.12    617.21    617.29    617.38    617.47    617.61    617.80    618.09    618.54
       619.34    620.44    621.56    622.69    623.82    624.95    626.08    627.21    627.89    628.06
     ..............................................................................................
                                           WATER POTENTIALS
     ..............................................................................................

     LAYER   1
       600.00    600.17    600.85    601.98    603.11    604.24    605.37    606.50    607.63    608.72
       608.51    608.87    610.26    610.45    610.58    610.66    610.76    610.85    610.93    611.02
       611.10    611.17    611.25    611.36    611.51    611.64    611.80    611.95    612.15    612.37
       612.03    612.85    613.02    613.20    613.36    613.49    613.64    613.75    613.83    613.90
       613.88    614.07    614.15    614.24    614.32    614.41    614.55    614.74    615.03    615.49
       616.26    617.36    618.50    619.63    620.76    621.89    623.02    624.15    624.83    625.00
     LAYER   2
       600.00    600.17    600.85    601.98    603.11    604.24    605.37    606.50    607.63    608.72
       608.52    608.88    610.27    610.46    610.59    610.68    610.77    610.86    610.94    611.03
       611.10    611.16    611.26    611.37    611.51    611.65    611.81    611.99    612.16    612.37
       612.03    612.85    613.01    613.19    613.35    613.49    613.63    613.74    613.82    613.90
       613.88    614.06    614.15    614.23    614.32    614.41    614.54    614.73    615.02    615.48
       616.26    617.36    618.50    619.63    620.76    621.89    623.02    624.15    624.83    625.00
     LAYER   3
       600.00    600.17    600.85    601.98    603.11    604.24    605.37    606.50    607.63    608.73
       608.54    610.01    610.31    610.50    610.64    610.73    610.82    610.91    610.99    611.08
       611.15    611.24    611.31    611.42    611.56    611.70    611.85    612.02    612.18    612.38
       612.02    612.82    612.98    613.15    613.30    613.44    613.58    613.69    613.76    613.84
       613.92    614.01    614.09    614.18    614.27    614.36    614.50    614.69    614.99    615.46
       616.27    617.36    618.50    619.63    620.76    621.89    623.02    624.15    624.83    625.00
     LAYER   4
       600.00    600.17    600.85    601.98    603.11    604.24    605.37    606.50    607.63    608.76
       608.58    610.08    610.39    610.59    610.74    610.83    610.93    611.02    611.10    611.19
       611.27    611.35    611.43    611.54    611.67    611.79    611.93    612.09    612.22    612.40
       612.50    612.78    612.91    613.07    613.21    613.33    613.46    613.57    613.65    613.73
       613.61    613.90    613.98    614.07    614.17    614.26    614.41    614.61    614.92    615.41
       616.24    617.37    618.50    619.63    620.76    621.89    623.02    624.15    624.83    625.00
     LAYER   5
       600.00    600.17    600.85    601.98    603.11    604.24    605.37    606.51    607.64    608.78
       608.65    610.16    610.50    610.73    610.89    610.99    611.09    611.19    611.29    611.37
       611.46    611.54    611.61    611.72    611.84    611.95    612.07    612.19    612.30    612.42
       612.58    612.70    612.81    612.93    613.05    613.16    613.28    613.39    613.46    613.54
       613.63    613.71    613.81    613.91    614.01    614.11    614.27    614.50    614.84    615.35
       616.23    617.36    618.49    619.63    620.76    621.89    623.02    624.15    624.83    625.00
     LAYER   6
       600.00    600.17    600.85    601.98    603.11    604.24    605.37    606.51    607.65    608.80
       608.69    610.24    610.61    610.88    611.05    611.17    611.28    611.40    611.50    611.60
       611.69    611.77    611.84    611.94    612.04    612.13    612.22    612.30    612.37    612.45
       612.55    612.63    612.70    612.78    612.87    612.96    613.06    613.16    613.23    613.31
       613.40    613.50    613.60    613.71    613.83    613.95    614.14    614.39    614.76    615.31
       616.20    617.35    618.49    619.63    620.76    621.89    623.02    624.15    624.83    625.00
     LAYER   7
       600.00    600.17    600.85    601.98    603.11    604.24    605.37    606.51    607.65    608.80
       608.71    610.27    610.66    610.93    611.14    611.27    611.40    611.52    611.64    611.74
       611.84    611.92    611.98    612.07    612.16    612.23    612.30    612.36    612.41    612.47
       612.53    612.59    612.64    612.70    612.77    612.84    612.93    613.02    613.08    613.15
       613.26    613.35    613.46    613.60    613.73    613.86    614.07    614.34    614.73    615.29
       616.20    617.35    618.49    619.63    620.76    621.89    623.02    624.15    624.83    625.00
     LAYER   8
       600.00    600.17    600.85    601.98    603.11    604.24    605.37    606.51    607.65    608.81
       608.71    610.29    610.69    610.97    611.19    611.33    611.47    611.61    611.73    611.84
       611.93    612.01    612.07    612.15    612.23    612.29    612.34    612.40    612.43    612.46
       612.52    612.57    612.60    612.65    612.71    612.77    612.85    612.93    612.99    613.07
       613.16    613.27    613.39    613.53    613.67    613.81    614.03    614.31    614.71    615.29
       616.19    617.35    618.49    619.63    620.76    621.89    623.02    624.15    624.83    625.00
     LAYER   9
       600.00    600.17    600.85    601.98    603.11    604.24    605.37    606.51    607.65    608.81
       608.72    610.30    610.72    611.01    611.24    611.39    611.55    611.70    611.83    611.95
       612.04    612.12    612.17    612.24    612.31    612.35    612.39    612.43    612.46    612.49
       612.52    612.54    612.57    612.61    612.65    612.69    612.75    612.83    612.88    612.95
       613.05    613.17    613.30    613.45    613.61    613.78    613.99    614.28    614.70    615.28
       616.19    617.35    618.49    619.63    620.76    621.89    623.02    624.15    624.83    625.00
     LAYER  10
       600.00    600.17    600.85    601.98    603.11    604.24    605.37    606.51    607.65    608.81
       608.73    610.31    610.74    611.04    611.28    611.46    611.63    611.80    611.96    612.08
       612.17    612.24    612.29    612.34    612.38    612.42    612.44    612.47    612.48    612.49
       612.51    612.52    612.53    612.56    612.58    612.61    612.66    612.71    612.76    612.83
       612.93    613.04    613.20    613.37    613.54    613.71    613.96    614.26    614.69    615.27
       616.19    617.35    618.49    619.63    620.76    621.89    623.02    624.15    624.83    625.00
     LAYER  11
       600.00    600.17    600.85    601.98    603.11    604.24    605.37    606.51    607.65    608.81
       608.73    610.32    610.75    611.06    611.32    611.50    611.70    611.89    612.07    612.20
       612.28    612.35    612.38    612.41    612.46    612.47    612.48    612.49    612.49    612.50
       612.50    612.51    612.51    612.52    612.53    612.54    612.59    612.62    612.65    612.72
       612.80    612.93    613.11    613.30    613.50    613.68    613.94    614.25    614.68    615.27
       616.19    617.35    618.49    619.63    620.76    621.89    623.02    624.15    624.83    625.00
     LAYER  12
       600.00    600.17    600.85    601.98    603.11    604.24    605.37    606.51    607.65    608.81
       608.73    610.32    610.76    611.07    611.34    611.53    611.74    611.95    612.15    612.30
       612.36    612.43    612.45    612.46    612.48    612.49    612.49    612.49    612.49    612.50
       612.50    612.51    612.51    612.51    612.51    612.52    612.54    612.55    612.57    612.64
       612.70    612.84    613.04    613.26    613.47    613.66    613.93    614.24    614.68    615.27
       616.19    617.35    618.49    619.63    620.76    621.89    623.02    624.15    624.83    625.00
     LAYER  13
       600.00    600.17    600.85    601.98    603.11    604.24    605.37    606.51    607.65    608.82
       608.73    610.33    610.76    611.08    611.36    611.56    611.78    612.02    612.27    612.41
       612.44    612.48    612.49    612.49    612.49    612.49    612.49    612.49    612.49    612.50
       612.50    612.51    612.51    612.51    612.51    612.52    612.52    612.52    612.52    612.56
       612.59    612.73    612.97    613.22    613.44    613.64    613.92    614.24    614.67    615.27
       616.18    617.35    618.49    619.63    620.76    621.89    623.02    624.15    624.83    625.00
     LAYER  14
       600.00    600.17    600.85    601.98    603.11    604.24    605.37    606.51    607.65    608.82
       608.74    610.33    610.77    611.09    611.37    611.57    611.81    612.10    612.38    612.48
       612.48    612.49    612.49    612.49    612.49    612.49    612.49    612.49    612.49    612.50
       612.50    612.51    612.51    612.51    612.51    612.52    612.52    612.52    612.52    612.52
       612.52    612.61    612.90    613.18    613.43    613.63    613.91    614.23    614.67    615.26
       616.18    617.35    618.49    619.63    620.76    621.89    623.02    624.15    624.83    625.00
     LAYER  15
       600.00    630.17    600.85    601.98    603.11    604.24    605.37    606.51    607.65    608.82
       608.74    610.33    610.77    611.09    611.37    611.58    611.83    612.17    612.48    612.48
       612.48    612.48    612.48    612.48    612.49    612.49    612.49    612.49    612.49    612.50
       612.50    612.51    612.51    612.51    612.51    612.52    612.52    612.52    612.52    612.52
       612.52    612.52    612.83    613.17    613.42    613.63    613.91    614.23    614.67    615.26
       616.18    617.35    618.49    619.63    620.76    621.89    623.02    624.15    624.83    625.00
     LAYER  16
       600.00    600.17    600.85    601.98    603.11    604.24    605.37    606.51    607.65    608.82
       608.74    610.33    610.77    611.09    611.37    611.58    611.83    612.17    612.48    612.48
       612.48    612.48    612.48    612.48    612.48    612.49    612.49    612.49    612.49    612.50
       612.50    612.51    612.51    612.51    612.51    612.52    612.52    612.52    612.52    612.52
       612.52    612.52    612.83    613.17    613.42    613.63    613.91    614.23    614.67    615.28
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Listing of S720UT at 02:52:52 on FEB  3, 1988 for CCid=BENR on UALTAMTS                                 Page   23
2729       616.18   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
2730     LAYER  17
2731       600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.82
2732       609.74   610.33   610.77   611.08   611.37   611.57   611.61   612.10   612.39   612.46
2733       612.48   612.48   612.46   612.48   612.48   612.49   612.49   612.49   612.49   612.50
2734       612.50   612.51   612.51   612.51   612.51   612.52   612.52   612.52   612.52   612.52
2735       612.52   612.61   612.90   613.19   613.43   613.63   613.91   614.23   614.57   615.26
2736       616.18   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
2737     LAYER  18
2738       600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.82
2739       609.73   610.33   610.76   611.08   611.36   611.56   611.78   612.03   612.27   612.41
2740       612.44   612.48   612.48   612.48   612.48   612.49   612.49   612.49   612.49   612.50
2741       612.50   612.51   612.51   612.51   612.51   612.52   612.52   612.52   612.52   612.56
2742       612.59   612.72   612.97   613.22   613.44   613.64   613.92   614.24   614.57   615.27
2743       616.18   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
2744     LAYER  19
2745       600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.81
2746       609.73   610.32   610.76   611.07   611.34   611.53   611.74   611.96   612.16   612.30
2747       612.36   612.43   612.46   612.48   612.48   612.49   612.49   612.49   612.48   612.50
2748       612.50   612.51   612.51   612.51   612.51   612.52   612.54   612.55   612.57   612.64
2749       612.70   612.84   613.04   613.26   613.47   613.66   613.93   614.24   614.66   615.27
2750       616.18   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
2751     LAYER  20
2752       600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.81
2753       609.73   610.32   610.75   611.06   611.32   611.50   611.70   611.89   612.07   612.20
2754       612.28   612.35   612.38   612.41   612.46   612.47   612.46   612.49   612.48   612.50
2755       612.50   612.51   612.51   612.52   612.53   612.54   612.59   612.62   612.68   612.72
2756       612.80   612.93   613.11   613.30   613.50   613.68   613.94   614.25   614.66   615.27
2757       616.18   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
2758     LAYER  21
2759       600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.81
2760       609.72   610.31   610.74   611.04   611.29   611.46   611.63   611.80   611.96   612.08
2761       612.17   612.24   612.29   612.34   612.39   612.42   612.44   612.47   612.48   612.49
2762       612.51   612.52   612.53   612.56   612.58   612.61   612.66   612.71   612.76   612.83
2763       612.92   613.04   613.20   613.37   613.54   613.71   613.96   614.26   614.69   615.27
2764       616.19   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
2765     LAYER  22
2766       600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.81
2767       609.72   610.30   610.72   611.01   611.24   611.38   611.55   611.70   611.82   611.95
2768       612.04   612.12   612.17   612.24   612.31   612.36   612.39   612.43   612.46   612.48
2769       612.52   612.54   612.57   612.61   612.65   612.69   612.76   612.83   612.88   612.98
2770       613.05   613.17   613.30   613.45   613.61   613.76   613.99   614.26   614.70   615.26
2771       616.19   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
2772     LAYER  23
2773       600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.81
2774       609.71   610.28   610.69   610.97   611.18   611.33   611.47   611.61   611.73   611.84
2775       611.93   612.01   612.07   612.15   612.23   612.29   612.34   612.40   612.43   612.46
2776       612.52   612.57   612.60   612.66   612.71   612.77   612.85   612.93   612.99   613.07
2777       613.15   613.27   613.38   613.53   613.67   613.81   614.03   614.31   614.71   615.29
2778       616.19   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
2779     LAYER  24
2780       600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.80
2781       609.71   610.27   610.66   610.93   611.14   611.27   611.40   611.52   611.64   611.74
2782       611.84   611.92   611.98   612.07   612.16   612.23   612.30   612.36   612.41   612.47
2783       612.53   612.59   612.64   612.70   612.77   612.84   612.93   613.02   613.08   613.16
2784       613.28   613.36   613.46   613.60   613.73   613.85   614.07   614.34   614.73   615.29
2785       616.20   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
2786     LAYER  25
2787       600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.80
2788       609.59   610.24   610.61   610.86   611.05   611.17   611.28   611.40   611.50   611.59
2789       611.69   611.77   611.84   611.94   612.04   612.13   612.22   612.30   612.37   612.45
2790       612.55   612.63   612.70   612.78   612.87   612.96   613.06   613.16   613.22   613.31
2791       613.40   613.50   613.60   613.71   613.83   613.95   614.14   614.38   614.78   615.31
2792       616.20   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
2793     LAYER  26
2794       600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.64   608.78
2795       609.55   61C.16   610.50   610.73   610.89   610.99   611.09   611.19   611.29   611.37
2796       611.45   611.54   611.61   611.72   611.84   611.95   612.07   612.18   612.30   612.42
2797       612.58   612.70   612.81   612.93   613.05   613.16   613.28   613.38   613.46   613.54
2798       613.63   613.71   613.81   613.91   614.01   614.11   614.27   614.50   614 84   615.35
2799       616.22   617.36   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
2800     LAYER  27
2801       600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.50   607.63   608.76
2802       609.53   610.08   610.38   610.59   610.74   610.82   610.93   611.02   611.10   611.18
2803       611.27   611.35   611.43   611.54   611.67   611.79   611.93   612.09   612.22   612.40
2804       612.60   612.75   612.91   613.07   613.21   613.33   613.46   613.57   613.65   613.73
2805       613.81   613.90   613.98   614.07   614.17   614.26   614.41   614.61   614.93   615.41
2806       616.24   617.37   618.50   619.63   620.76   621.89   623.02   624.15   624.83   626.00
2807     LAYER  28
2808       600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.50   607.63   608.73
2809       609.54   610.01   610.31   610.50   610.64   610.73   610.82   610.91   610.99   611.06
2810       611.16   611.24   611.31   611.42   611.56   611.70   611.85   612.02   612.16   612.28
2811       612.62   612.82   612.98   613.15   613.30   613.44   613.58   613.69   613.78   613.84
2812       613.92   614.01   614.09   614.16   614.27   614.36   614.50   614.69   614.99   615.46
2813       616.27   617.38   618.50   619.63   620.76   621.89   623.02   624.15   624.83   626.00
2814     LAYER  29
2815       600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.50   607.63   608.72
2816       609.52   609.98   610.27   610.45   610.59   610.68   610.77   610.86   610.94   611.02
2817       611.10   611.18   611.26   611.37   611.51   611.65   611.81   611.98   612.15   612.27
2818       612.63   612.86   613.01   613.19   613.35   613.49   613.63   613.74   613.82   613.90
2819       613.98   614.06   614.15   614.23   614.32   614.41   614.54   614.73   615.02   615.48
2820       616.28   617.38   618.50   619.63   620.76   621.89   623.02   624.15   624.83   626.00
2821     LAYER  30
2822       600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.50   607.63   608.72
2823       609.51   609.97   610.28   610.45   610.59   610.68   610.76   610.85   610.93   611.02
2824       611.10   611.17   611.25   611.36   611.51   611.64   611.80   611.96   612.15   612.27
2825       612.63   612.85   613.02   613.20   613.36   613.49   613.64   613.75   613.83   613.90
2826       613.98   614.07   614.15   614.24   614.32   614.41   614.55   614.74   615.03   615.48
2827       616.28   617.38   618.50   619.63   620.76   621.89   623.02   624.15   624.83   626.00
2828   -  EOI ENCOUNTERED.
```

Appendix 3

Sample Computer Output, Case Two.

```
     ****************************************************************************
   ****************************************************************************
                              S W A N F L O W - 2 D

              SIMULTANEOUS WATER, AIR, AND NAPL FLOW IN TWO DIMENSIONS

                                   WRITTEN BY:

                                 CHARLES R. FAUST
                                JAMES O. RUMBAUGH

                                  GEOTRANS, INC.
                                250 EXCHANGE PLACE
                                     SUITE A
                                   HERNDON, VA
    ****************************************************************************
   ****************************************************************************

   LENS 10:1  GRADIENT = 0.02  EPSILON = 1000 ----STEADY STATE----
          DATE .... 02 FEB 1988                           RUN NO .... 7_1

        NUMBER OF BLOCKS IN THE X-DIRECTION (COLUMNS) =   60
        NUMBER OF BLOCKS IN THE Z-DIRECTION (LAYERS)  =   39
        MAXIMUM OF NEWTON-RAPHSON ITERATIONS          =    5
        MAXIMUM BANDWIDTH                             =    0
        MAXIMUM NUMBER OF TIME STEPS                  =   50
        NUMBER OF ACTIVE GRID BLOCKS                  = 1740
        NUMBER OF TIME STEPS BETWEEN PRINTOUTS        =   50
        PRINT NAPL AND WATER POTENTIALS? (1=YES)      =    1
        PRINT DETAILED KR TABLES?        (1=YES)      =    0
        WRITE A PLOT FILE?               (1=YES)      =    1
        NUMBER OF OBSERVATION BLOCKS                  =    0
        WRITE A RESTART FILE?            (1=YES)      =    1


                                                      =   1.0000
        GRID BLOCK THICKNESS (DY)                     =  0.10000E-01
        MASS BALANCE TOLERANCE FOR NEWTON-RAPHSON IT. =  0.00000E+00
        INITIAL TIME VALUE                            =   1000.0
        WATER DENSITY                                 =   850.00
        NAPL DENSITY                                  =  0.10000E-02
        WATER VISCOSITY                               =  0.30000E-02
        NAPL VISCOSITY                                =  -9.8100
        GRAVITATIONAL CONSTANT IN THE Z-DIRECTION     =  0.00000E+00
        GRAVITATIONAL CONSTANT IN THE X-DIRECTION


    ...................................................................................................
    .................................. 2 PC-KR TABLES WILL BE READ ...................................
    ...................................................................................................

                   ********** TABLE NUMBER    1 **********

         NAPL-WATER CAP.      WATER        RELATIVE PERM.   RELATIVE PERM.
            PRESSURE        SATURATION         WATER             NAPL
                                                                1.00000
        240000.00000         -0.05000         0.00000           1.00000
        240000.00000          0.00000         0.00000           1.00000
        240000.00000          0.05000         0.00000           1.00000
        240000.00000          0.10000         0.00000           1.00000
        240000.00000          0.15000         0.00000           1.00000
        240000.00000          0.20000         0.00000           1.00000
        240000.00000          0.25000         0.00000           1.00000
        240000.00000          0.30000         0.00000           1.00000
        150000.00000          0.35000         0.00000           1.00000
         60000.00000          0.40000         0.00000           1.00000
         45000.00000          0.45000         0.00500           0.50000
         30000.00000          0.50000         0.01200           0.25000
         21000.00000          0.55000         0.03500           0.12300
         15000.00000          0.60000         0.08700           0.05500
         13000.00000          0.65000         0.15200           0.02100
         11000.00000          0.70000         0.22700           0.00400
          8000.00000          0.75000         0.30000           0.00000
          7000.00000          0.80000         0.37500           0.00000
          6000.00000          0.85000         0.50000           0.00000
          5500.00000          0.90000         0.65000           0.00000
          5250.00000          0.95000         1.00000           0.00000
          5000.00000          1.00000         1.00000           0.00000
          5000.00000          1.05000

        AIR-NAPL SYSTEM -- PC-KR TABLE NUMBER    1
        NAPL KR AT RESIDUAL WATER SATURATION :    0.55000

         AIR-NAPL CAP.        AIR         RELATIVE PERM.   RELATIVE PERM.
           PRESSURE        SATURATION         NAPL              AIR
                                                               0.00000
        -5500.00000          1.00000         0.00000           0.00000
            0.00000          0.00000         0.00000

                   ********** TABLE NUMBER    2 **********

         NAPL-WATER CAP.      WATER        RELATIVE PERM.   RELATIVE PERM.
            PRESSURE        SATURATION         WATER             NAPL
                                                                1.00000
                            -0.05000          0.00000           1.00000
        480000.00000         0.00000          0.00000           1.00000
        480000.00000         0.05000          0.00000           1.00000
        480000.00000         0.10000          0.00000           1.00000
        480000.00000         0.15000          0.00000           1.00000
        480000.00000         0.20000          0.00000           1.00000
        480000.00000         0.25000          0.00000           1.00000
        480000.00000         0.30000          0.00000           1.00000
        480000.00000         0.35000          0.00000           1.00000
        480000.00000         0.40000          0.00000           1.00000
        480000.00000         0.45000          0.00000           1.00000
        480000.00000         0.50000          0.00500           0.50000
        480000.00000         0.55000          0.01200           0.25000
        480000.00000         0.60000          0.03500           0.12300
        350000.00000         0.65000          0.08700           0.05500
        240000.00000         0.70000          0.15200           0.02100
        140000.00000         0.75000          0.22700           0.00400
        110000.00000         0.80000          0.30000           0.00000
         87500.00000         0.85000          0.37500           0.00000
         70000.00000         0.90000          0.50000           0.00000
         55000.00000         0.95000          0.65000           0.00000
         40000.00000         1.00000          1.00000           0.00000
         30000.00000
```

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          20000.00000          1.05000          1.00000          0.00000

          AIR-NAPL SYSTEM -- PC-KR TABLE NUMBER   2
          NAPL KR AT RESIDUAL WATER SATURATION :    0.85000

           AIR-NAPL CAP.        AIR         RELATIVE PERM.  RELATIVE PERM.
             PRESSURE        SATURATION          NAPL             AIR

          -9800.00000          1.00000          0.00000          0.00000
              0.00000          0.00000          0.00000          0.00000
.........................................................................................................


.........................................................................................................
                                         2 PERMEABILITY SETS WILL BE READ
.........................................................................................................

 SET NUMBER      KX         KZ

          1 0.10000E-12 0.10000E-12
          2 0.10000E-15 0.10000E-15
.........................................................................................................
                                         2 POROSITY SETS WILL BE READ
.........................................................................................................

 SET NUMBER       REF. POROSITY  COMPRESSIBILITY  REF. PRESSURE

          1       0.20000          0.10000E-08      0.10000E+06
          2       0.50000E-01      0.10000E-08      0.10000E+06
.........................................................................................................
                                      GRID BLOCK SPACINGS IN THE X-DIRECTION
.........................................................................................................

     5.0000      10.000      50.000      50.000      50.000      50.000      50.000      50.000      50.000      50.000
     25.000      20.000      10.000      10.000      5.0000      5.0000      5.0000      5.0000      5.0000      5.0000
     5.0000      5.0000      5.0000      10.000      10.000      10.000      15.000      15.000      15.000      25.000
     25.000      15.000      15.000      15.000      10.000      10.000      10.000      5.0000      5.0000      5.0000
     5.0000      5.0000      5.0000      5.0000      5.0000      5.0000      10.000      10.000      20.000      25.000
     50.000      50.000      50.000      50.000      50.000      50.000      50.000      50.000      10.000      5.0000
.........................................................................................................
                                      GRID BLOCK SPACINGS IN THE Z-DIRECTION
.........................................................................................................

     5.0000      25.000      25.000      25.000      25.000      12.500      5.0000      5.0000      5.0000      5.0000
     2.5000      2.5000      2.5000      2.5000      2.5000      2.5000      2.5000      2.5000      2.5000      2.5000
     5.0000      5.0000      5.0000      5.0000      12.500      25.000      25.000      25.000      25.000      5.0000
.........................................................................................................
                                      THERE ARE    2 PROPERTY COMBINATION SETS
.........................................................................................................

     SET NUMBER      PC-KR TABLE   K CLASS   POROSITY CLASS

               1              1          1              1
               2              2          2              2

.........................................................................................................
                                      GRID BLOCK NUMBERS
.........................................................................................................

                     X-DIRECTION   ---->

     LAYER   1    -1   1  31  61  91 121 151 181 211 241 271 301 331 361 391 421 451 481 511 541 571 601 631 661 691
                 721 751 781 811 841 871 901 931 961 991102110511081111111411171120112311261129113211351138114111441
                147115011531156115911621165116811711  -1
     LAYER   2    -1   2  32  62  92 122 152 182 212 242 272 302 332 362 392 422 452 482 512 542 572 602 632 662 692
                 722 752 782 812 842 872 902 932 962 992102210521082111211421172120212321262129213221352138214121442
                147215021532156215921622165216821712  -1
     LAYER   3    -1   3  33  63  93 123 153 183 213 243 273 303 333 363 393 423 453 483 513 543 573 603 633 663 693
                 723 753 783 813 843 873 903 933 963 993102310531083111311431173120312331263129313231353138314131443
                147315031533156315931623165316831713  -1
     LAYER   4    -1   4  34  64  94 124 154 184 214 244 274 304 334 364 394 424 454 484 514 544 574 604 634 664 694
                 724 754 784 814 844 874 904 934 964 994102410541084111411441174120412341264129413241354138414141444
                147415041534156415941624165416841714  -1
     LAYER   5    -1   5  35  65  95 125 155 185 215 245 275 305 335 365 395 425 455 485 515 545 575 605 635 665 695
                 725 755 785 815 845 875 905 935 965 995102510551085111511451175120512351265129513251355138514151445
                147515051535156515951625165516851715  -1
     LAYER   6    -1   6  36  66  96 126 156 186 216 246 276 306 336 366 396 426 456 486 516 546 576 606 636 666 696
                 726 756 786 816 846 876 906 936 966 996102610561086111611461176120612361266129613261356138614161446
                147615061536156615961626165616861716  -1
     LAYER   7    -1   7  37  67  97 127 157 187 217 247 277 307 337 367 397 427 457 487 517 547 577 607 637 667 697
                 727 757 787 817 847 877 907 937 967 997102710571087111711471177120712371267129713271357138714171447
                147715071537156715971627165716871717  -1
     LAYER   8    -1   8  38  68  98 128 158 188 218 248 278 308 338 368 398 428 458 488 518 548 578 608 638 668 698
                 728 758 788 818 848 878 908 938 968 998102810581088111811481178120812381268129813281358138814181448
                147815081538156815981628165816881718  -1
     LAYER   9    -1   9  39  69  99 129 159 189 219 249 279 309 339 369 399 429 459 489 519 549 579 609 639 669 699
                 729 759 789 819 849 879 909 939 969 999102910591089111911491179120912391269129913291359138914191449
                147915091539156915991629165916891719  -1
     LAYER  10    -1  10  40  70 100 130 160 190 220 250 280 310 340 370 400 430 460 490 520 550 580 610 640 670 700
                 730 760 790 820 850 880 910 940 9701000103010601090112011501180121012401270130013301360139014201450
                148015101540157016001630166016901720  -1
     LAYER  11    -1  11  41  71 101 131 161 191 221 251 281 311 341 371 401 431 461 491 521 551 581 611 641 671 701
                 731 761 791 821 851 881 911 941 9711001103110611091112111511181121112411271130113311361139114211451
                148115111541157116011631166116911721  -1
     LAYER  12    -1  12  42  72 102 132 162 192 222 252 282 312 342 372 402 432 462 492 522 552 582 612 642 672 702
                 732 762 792 822 852 882 912 942 9721002103210621092112211521182121212421272130213321362139214221452
                148215121542157216021632166216921722  -1
     LAYER  13    -1  13  43  73 103 133 163 193 223 253 283 313 343 373 403 433 463 493 523 553 583 613 643 673 703
                 733 763 793 823 853 883 913 943 9731003103310631093112311531183121312431273130313331363139314231453
                148315131543157316031633166316931723  -1
     LAYER  14    -1  14  44  74 104 134 164 194 224 254 284 314 344 374 404 434 464 494 524 554 584 614 644 674 704
                 734 764 794 824 854 884 914 944 9741004103410641094112411541184121412441274130413341364139414241454
                148415141544157416041634166416941724  -1
     LAYER  15    -1  15  45  75 105 135 165 195 225 255 285 315 345 375 405 435 465 495 525 555 585 615 645 675 705
                 735 765 795 825 855 885 915 945 9751005103510651095112511551185121512451275130513351365139514251455
                148515151545157516051635166516951725  -1
     LAYER  16    -1  16  46  76 106 136 166 196 226 256 286 316 346 376 406 436 466 496 526 556 586 616 646 676 706
                 736 766 796 826 856 886 916 946 9761006103610661096112611561186121612461276130613361366139614261456
                148615161546157616061636166616961726  -1
     LAYER  17    -1  17  47  77 107 137 167 197 227 257 287 317 347 377 407 437 467 497 527 557 587 617 647 677 707
                 737 767 797 827 857 887 917 947 9771007103710671097112711571187121712471277130713371367139714271457
                148715171547157716071637166716971727  -1
     LAYER  18    -1  18  48  78 108 138 168 198 228 258 288 318 348 378 408 438 468 498 528 558 588 618 648 678 708
                 738 768 798 828 858 888 918 948 9781008103810681098112811581188121812481278130813381368139814281458
                148815181548157816081638166816981728  -1
     LAYER  19    -1  19  49  79 109 139 169 199 229 259 289 319 349 379 409 439 469 499 529 559 589 619 649 679 709
                 739 769 799 829 859 889 919 949 9791009103910691099112911591189121912491279130913391369139914291459
                148915191549157916091639166916991729  -1
```

```
Listing of STIOUT at 02:52:35 on FEB  5, 1986 for CCid=BENR on WALTAMTS
LAYER  20     -1  20  50  80 110 140 170 200 230 260 290 320 350 380 410 440 470 500 530 560 590 620 650 680 710
             740 770 800 830 860 890 920 950 9801010104010701100113011601190122012501280131013401370140014301460
            149015201550158016101640167017001730  -1
LAYER  21     -1  21  51  81 111 141 171 201 231 261 291 321 351 381 411 441 471 501 531 561 591 621 651 681 711
             741 771 801 831 861 891 921 951 9811011104110711101113111611191122112511281131113411371140114311461
            149115211551158116111641167117011731  -1
LAYER  22     -1  22  52  82 112 142 172 202 232 262 292 322 352 382 412 442 472 502 532 562 592 622 652 682 712
             742 772 802 832 862 892 922 952 9821012104210721102113211621192122212521282131213421372140214321462
            149215221552158216121642167217021732  -1
LAYER  23     -1  23  53  83 113 143 173 203 233 263 293 323 353 383 413 443 473 503 533 563 593 623 653 683 713
             743 773 803 833 863 893 923 953 9831013104310731103113311631193122312531283131313431373140314331463
            149315231553158316131643167317031733  -1
LAYER  24     -1  24  54  84 114 144 174 204 234 264 294 324 354 384 414 444 474 504 534 564 594 624 654 684 714
             744 774 804 834 864 894 924 954 9841014104410741104113411641194122412541284131413441374140414341464
            149415241554158416141644167417041734  -1
LAYER  25     -1  25  55  85 115 145 175 205 235 265 295 325 355 385 415 445 475 505 535 565 595 625 655 685 715
             745 775 805 835 865 895 925 955 9851015104510751105113511651195122512551285131513451375140514351465
            149515251555158516151645167517051735  -1
LAYER  26     -1  26  56  86 116 146 176 206 236 266 296 326 356 386 416 446 476 506 536 566 596 626 656 686 716
             746 776 806 836 866 896 926 956 9861016104610761106113611661196122612561286131613461376140614361466
            149615261556158616161646167617061736  -1
LAYER  27     -1  27  57  87 117 147 177 207 237 267 297 327 357 387 417 447 477 507 537 567 597 627 657 687 717
             747 777 807 837 867 897 927 957 9871017104710771107113711671197122712571287131713471377140714371467
            149715271557158716171647167717071737  -1
LAYER  28     -1  28  58  88 118 148 178 208 238 268 298 328 358 388 418 448 478 508 538 568 598 628 658 688 718
             748 778 808 838 868 898 928 958 9881018104810781108113811681198122812581288131813481378140814381468
            149815281558158816181648167817081738  -1
LAYER  29     -1  29  59  89 119 149 179 209 239 269 299 329 359 389 419 449 479 509 539 569 599 629 659 689 719
             749 779 809 839 869 899 929 959 9891019104910791109113911691199122912591289131913491379140914391469
            149915291559158916191649167917091739  -1
LAYER  30     -1  30  60  90 120 150 180 210 240 270 300 330 360 390 420 450 480 510 540 570 600 630 660 690 720
             750 780 810 840 870 900 930 960 9901020105010801110114011701200123012601290132013501380141014401470
            150015301560159016201650168017101740  -1
..............................................................................................................
.......................................... PROPERTY CLASS NUMBERS ...........................................
..............................................................................................................

                    X-DIRECTION  -- I INDEX
              1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25
             26  27  28  29  30  31  32  33  34  35  36  37  38  39  40  41  42  43  44  45  46  47  48  49  50
             51  52  53  54  55  56  57  58  59  60
LAYER   1     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER   2     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER   3     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER   4     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER   5     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER   6     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
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              2   2   2   2   2   2   2   2   2   2
LAYER   7     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER   8     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER   9     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  10     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  11     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   1   1   1   1   1   1   2   2
LAYER  12     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   1
              2   2   2   2   2   2   2   2   2   2   1   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              1   1   1   1   1   1   1   1   1   1
LAYER  13     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   1   1   1   1
              2   2   2   2   2   2   2   2   2   2   1   1   1   1   2   2   2   2   2   2   2   2   2   2   2
              1   1   1   1   1   1   1   1   1   1
LAYER  14     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   1   1   1   1   1   1
              2   2   2   2   2   2   2   2   2   2   1   1   1   1   1   1   2   2   2   2   2   2   2   2   2
              1   1   1   1   1   1   1   1   1   1
LAYER  15     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   1   1   1   1   1   1   1
              2   2   2   2   2   2   2   2   2   2   1   1   1   1   1   1   1   2   2   2   2   2   2   2   2
              1   1   1   1   1   1   1   1   1   1
LAYER  16     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   1   1   1   1   1   1   1
              2   2   2   2   2   2   2   2   2   2   1   1   1   1   1   1   1   2   2   2   2   2   2   2   2
              1   1   1   1   1   1   1   1   1   1
LAYER  17     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   1   1   1   1   1   1
              2   2   2   2   2   2   2   2   2   2   1   1   1   1   1   1   2   2   2   2   2   2   2   2   2
              1   1   1   1   1   1   1   1   1   1
LAYER  18     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   1   1   1   1
              2   2   2   2   2   2   2   2   2   2   1   1   1   1   2   2   2   2   2   2   2   2   2   2   2
              1   1   1   1   1   1   1   1   1   1
LAYER  19     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   1
              2   2   2   2   2   2   2   2   2   2   1   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              1   1   1   1   1   1   1   1   1   1
LAYER  20     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   1   1   1   1   1   1   2   2
LAYER  21     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  22     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  23     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  24     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  25     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  26     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  27     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
              2   2   2   2   2   2   2   2   2   2
LAYER  28     2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
```

```
                 2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
                 2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
   LAYER  29     2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
                 2  2  2  2  2  2  2  2  2  2
                 2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
   LAYER  30     2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
                 2  2  2  2  2  2  2  2  2  2
                 2  2  2  2  2  2  2  2  2  2

  ********** CALCULATED MAXIMUM BANDWIDTH =  123 **********
  ..........................................................................................
                                  INITIAL CONDITION DATA
  ..........................................................................................

  ..........................................................................................
                                  INITIAL NAPL PRESSURES
  ..........................................................................................

  LAYER    1
  [illegible]
  LAYER    2
  [illegible]
  LAYER    3
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  LAYER    4
  [illegible]
  LAYER    5
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  LAYER    6
  [illegible]
  LAYER    7
  [illegible]
  LAYER    8
  [illegible]
  LAYER    9
  [illegible]
  LAYER   10
  [illegible]
  LAYER   11
  [illegible]
  LAYER   12
  [illegible]
  LAYER   13
  [illegible]
  LAYER   14
  [illegible]
  LAYER   15
  [illegible]
```

```
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[illegible]
        LAYER   17
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[illegible]
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[illegible]
        LAYER   18
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        LAYER   19
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        LAYER   20
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        LAYER   21
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        LAYER   22
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        LAYER   23
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        LAYER   26
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[illegible]
        LAYER   27
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[illegible]
        LAYER   28
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        LAYER   29
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[illegible]
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[illegible]
        LAYER   30
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
 ...........................................................................................................
                                          INITIAL WATER SATURATIONS
 ...........................................................................................................

        LAYER    1
          1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
          1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
          1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
          1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
          1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
          1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
        LAYER    2
          1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
          1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
          1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
          1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
          1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
          1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000      1.0000
        LAYER    3
```

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Listing of E71OUT at 02:52:35 on FEB  8, 1985 for CCid=SEHR on WALTAMTS                                     Page    8
   621         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   622         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   623         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   624         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   625         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   626         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   627      LAYER    4
   628         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   629         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   630         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   631         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   632         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   633         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   634      LAYER    5
   635         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   636         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   637         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   638         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   639         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   640         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   641      LAYER    6
   642         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   643         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   644         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   645         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   646         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   647         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   648      LAYER    7
   649         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   650         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   651         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   652         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   653         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   654         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   655      LAYER    8
   656         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   657         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   658         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   659         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   660         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   661         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   662      LAYER    9
   663         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   664         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   665         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   666         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   667         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   668         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   669      LAYER   10
   670         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   671         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   672         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   673         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   674         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   675         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   676      LAYER   11
   677         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   678         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   679         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   680         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   681         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   682         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   683      LAYER   12
   684         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   685         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   686         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   687         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   688         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   689         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   690      LAYER   13
   691         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   692         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   693         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   694         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   695         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   696         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   697      LAYER   14
   698         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   699         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   700         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   701         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   702         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   703         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   704      LAYER   15
   705         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   706         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   707         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   708         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   709         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   710         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   711      LAYER   16
   712         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   713         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   714         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   715         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   716         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   717         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   718      LAYER   17
   719         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   720         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   721         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   722         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   723         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   724         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   725      LAYER   18
   726         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   727         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   728         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   729         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   730         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   731         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   732      LAYER   19
   733         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   734         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   735         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   736         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   737         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   738         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   739      LAYER   20
   740         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   741         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   742         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   743         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
   744         1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
```

```
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  21
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  22
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  23
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  24
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  25
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  26
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  27
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  28
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  29
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
    LAYER  30
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
 ..................................................................................................................
                                           RECURRENT DATA SET
 ..................................................................................................................

      INITIAL TIME STEP SIZE =  0.86400E+06
      MINIMUM TIME STEP SIZE =   3600.0
      MAXIMUM WATER SATURATION CHANGE =  0.10000
      TIME STEP MULTIPLIER =     1.2500
      TIME TO READ NEW RECURRENT DATA =  0.10000E+17
      NUMBER OF SOURCE/SINK BLOCKS =     0
      CODE FOR CHANGING FLUX RATES =     0

 ..................................................................................................................
 ..................................................................................................................
 ............................. TIME STEP NUMBER =     1          TIME VALUE =  0.86400E+06 .........................
 ..................................................................................................................

                    WATER BALANCE             NAPL BALANCE
      CONSTANT PRES     2.7694                 0.00000E+00
      SOURCE/SINKS      0.00000E+00            0.00000E+00
      STORAGE          -2.7694                 0.00000E+00
      PER CENT ERROR    0.24251E-06            0.00000E+00

          STEP NUMBER    1 COMPLETED          SIMULATION TIME IN SECONDS 0.864E+06
          *************************                           IN MINUTES 0.144E+05
                                                              IN HOURS    240.
                                                              IN DAYS     10.00
                                                              IN YEARS   0.274E-01
 ..................................................................................................................
 ............................. TIME STEP NUMBER =     2          TIME VALUE =  0.19440E+07 .........................
 ..................................................................................................................

                    WATER BALANCE             NAPL BALANCE
      CONSTANT PRES     2.7672                 0.00000E+00
      SOURCE/SINKS      0.00000E+00            0.00000E+00
      STORAGE          -2.7672                 0.00000E+00
      PER CENT ERROR   -0.77121E-07            0.00000E+00

          STEP NUMLER    2 COMPLETED          SIMULATION TIME IN SECONDS 0.194E+07
          *************************                           IN MINUTES 0.324E+05
                                                              IN HOURS    540.
                                                              IN DAYS     22.5
                                                              IN YEARS   0.616E-01
 ..................................................................................................................
 ............................. TIME STEP NUMBER =     3          TIME VALUE =  0.32940E+07 .........................
 ..................................................................................................................

                    WATER BALANCE             NAPL BALANCE
      CONSTANT PRES     2.7275                 0.00000E+00
      SOURCE/SINKS      0.00000E+00            0.00000E+00
```

```
2109      LAYER  20
2110         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2111         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2112         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2113         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2114         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2115         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2116      LAYER  21
2117         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2118         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2119         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2120         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2121         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2122         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2123      LAYER  22
2124         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2125         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2126         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2127         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2128         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2129         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2130      LAYER  23
2131         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2132         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2133         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2134         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2135         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2136         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2137      LAYER  24
2138         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2139         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2140         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2141         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2142         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2143         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2144      LAYER  25
2145         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2146         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2147         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2148         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2149         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2150         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2151      LAYER  26
2152         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2153         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2154         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2155         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2156         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2157         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2158      LAYER  27
2159         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2160         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2161         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2162         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2163         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2164         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2165      LAYER  28
2166         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2167         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2168         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2169         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2170         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2171         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2172      LAYER  29
2173         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2174         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2175         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2176         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2177         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2178         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2179      LAYER  30
2180         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2181         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2182         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2183         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2184         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2185         1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000     1.0000
2186     ..............................................................................................................
2187                                                   NAPL SATURATIONS
2188     ..............................................................................................................
2189
2190      LAYER   1
2191       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2192       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2193       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2194       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2195       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2196       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2197      LAYER   2
2198       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2199       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2200       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2201       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2202       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2203       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2204      LAYER   3
2205       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2206       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2207       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2208       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2209       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2210       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2211      LAYER   4
2212       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2213       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2214       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2215       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2216       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2217       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2218      LAYER   5
2219       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2220       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2221       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2222       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2223       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2224       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2225      LAYER   6
2226       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2227       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2228       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2229       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2230       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2231       0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
2232      LAYER   7
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  0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
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 LAYER   8
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 LAYER   9
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 LAYER  10
  0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
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 LAYER  11
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 LAYER  12
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 LAYER  13
  0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
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 LAYER  14
  0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
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 LAYER  15
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 LAYER  16
  0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
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 LAYER  17
  0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
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 LAYER  19
  0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
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 LAYER  20
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 LAYER  24
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     LAYER  26
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     LAYER  27
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     LAYER  29
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     LAYER  30
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                                                 NAPL POTENTIALS
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     LAYER    1
        708.46       709.88       710.48       711.81       713.14       714.47       715.80       717.12       718.44       719.74
        720.67       721.21       721.55       721.77       721.84       722.04       722.14       722.24       722.34       722.44
        722.53       722.63       722.72       722.85       723.02       723.18       723.36       723.56       723.76       724.03
        724.34       724.50       724.80       725.01       725.20       725.36       725.52       725.66       725.78       725.84
        726.03       726.03       726.13       726.22       726.33       726.44       726.80       726.83       727.16       727.70
        728.63       729.83       731.35       732.57       733.90       735.23       736.56       737.89       738.83       738.80
     LAYER    2
        712.13       712.33       713.13       714.46       715.79       717.12       718.45       719.77       721.08       722.38
        723.32       723.86       724.31       724.43       724.59       724.69       724.80       724.90       725.00       725.08
        725.19       725.26       725.37       725.50       725.67       725.83       726.02       726.23       726.43       726.66
        726.99       727.24       727.44       727.65       727.84       728.00       728.18       728.30       728.38       728.46
        728.57       728.67       728.77       728.87       728.97       729.08       729.24       729.49       729.80       730.24
        731.28       732.58       733.90       735.23       736.55       737.88       739.21       740.54       741.34       741.64
     LAYER    3
        715.84       716.74       717.84       718.87       720.20       721.53       722.86       724.19       725.51       726.83
        727.77       728.32       728.57       728.80       729.05       729.17       729.27       729.37       729.47       729.57
        729.67       729.76       729.85       729.96       730.14       730.30       730.46       730.66       730.87       731.10
        731.30       731.52       731.81       732.01       732.18       732.35       732.51       732.64       732.73       732.83
        732.83       733.02       733.12       733.22       733.32       733.43       733.60       733.83       734.17       734.72
        735.87       736.88       738.30       739.63       740.96       742.29       743.62       744.95       745.76       745.88
     LAYER    4
        720.85       721.15       721.95       723.28       724.61       725.94       727.27       728.60       729.93       731.26
        732.23       732.80       733.17       733.41       733.56       733.70       733.80       733.91       734.01       734.11
        734.21       734.30       734.39       734.52       734.66       734.82       734.99       735.17       735.32       735.54
        735.76       735.98       736.16       736.32       736.45       736.63       736.78       736.92       737.01       737.10
        737.20       737.30       737.40       737.51       737.62       737.73       737.90       738.14       738.51       739.08
        740.05       741.38       742.71       744.04       745.37       746.70       748.03       749.36       750.16       750.35
     LAYER    5
        725.36       725.86       726.36       727.69       729.02       730.35       731.68       733.02       734.35       735.68
        736.71       737.32       737.72       737.98       738.17       738.29       738.41       738.52       738.64       738.74
        738.84       738.94       739.03       739.15       739.30       739.42       739.58       739.71       739.83       739.98
        740.10       740.21       740.43       740.57       740.71       740.84       740.98       741.11       741.20       741.29
        741.39       741.50       741.61       741.72       741.84       741.97       742.15       742.42       742.82       743.43
        744.44       745.78       747.12       748.45       749.78       751.12       752.45       753.78       754.87       754.77
     LAYER    6
        728.67       728.87       729.87       731.00       732.33       733.66       734.99       736.32       737.67       739.02
        740.07       740.72       741.15       741.45       741.67       741.81       741.95       742.08       742.21       742.32
        742.42       742.53       742.60       742.72       742.84       742.94       743.04       743.14       743.23       743.32
        743.42       743.52       743.61       743.71       743.81       743.91       744.04       744.18       744.33       744.33
        744.43       744.55       744.67       744.80       744.94       745.08       745.30       745.60       746.04       746.66
        747.73       749.09       750.43       751.76       753.09       754.42       755.75       757.09       757.88       758.06
     LAYER    7
        730.22       730.42       731.21       732.54       733.87       735.21       736.54       737.87       739.21       740.57
        741.63       742.30       742.76       743.06       743.33       743.47       743.63       743.77       743.91       744.03
        744.14       744.23       744.31       744.43       744.53       744.60       744.68       744.76       744.83       744.88
        744.96       745.03       745.09       745.16       745.24       745.33       745.43       745.53       745.61       745.70
        745.81       745.93       746.07       746.21       746.37       746.53       746.75       747.06       747.55       748.21
        749.27       750.63       751.97       753.30       754.64       755.97       757.30       758.63       759.43       759.83
     LAYER    8
        731.10       731.30       732.10       733.43       734.76       736.09       737.42       738.76       740.10       741.45
        742.53       743.20       743.68       744.01       744.28       744.42       744.59       744.75       744.90       745.02
        745.13       745.23       745.30       745.40       745.49       745.55       745.62       745.66       745.73       745.76
        745.83       745.88       745.93       745.99       746.05       746.12       746.21       746.31       746.38       746.47
        746.58       746.71       746.86       747.01       747.16       747.35       747.60       747.93       748.41       749.06
        750.15       751.51       752.85       754.18       755.51       756.85       758.18       759.51       760.31       760.51
     LAYER    9
        731.98       732.18       732.98       734.31       735.64       736.97       738.30       739.64       740.98       742.35
        743.42       744.10       744.59       744.93       745.20       745.30       745.57       745.74       745.90       746.04
        746.15       746.23       746.30       746.38       746.46       746.51       746.56       746.61       746.64       746.67
        746.70       746.74       746.77       746.81       746.86       746.91       746.98       747.07       747.14       747.22
        747.34       747.47       747.63       747.81       747.99       748.17       748.40       748.74       749.27       749.95
        751.02       752.36       753.73       755.07       756.40       757.73       759.06       760.39       761.19       761.39
     LAYER   10
        732.88       733.08       733.88       735.19       736.52       737.85       739.19       740.52       741.86       743.22
        744.31       745.00       745.50       745.85       746.14       746.34       746.55       746.75       746.93       747.07
        747.18       747.26       747.32       747.36       747.44       747.47       747.50       747.53       747.55       747.56
        747.58       747.59       747.60       747.64       747.67       747.70       747.75       747.82       747.87       747.96
        748.06       748.21       748.38       748.58       748.76       748.99       749.26       749.64       750.14       750.83
        751.91       753.27       754.62       755.96       757.29       758.61       759.95       761.28       762.07       762.27
     LAYER   11
        733.82       733.72       734.52       735.85       737.16       738.52       739.85       741.18       742.53       743.88
        744.97       745.66       746.17       746.54       746.84       747.05       747.29       747.52       747.73       747.88
        747.98       748.05       748.08       748.12       748.16       748.19       748.20       748.22       748.22       748.22
        748.23       748.24       748.24       748.26       748.27       748.28       748.24       748.27       748.41       748.48
        748.58       748.72       748.84       749.13       749.40       749.62       749.82       750.20       750.80       751.40
        752.67       753.93       755.30       756.61       757.95       759.28       760.61       761.94       762.74       762.84
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Listing of S71OUT at 02:52:35 on FEB  5, 1988 for CCid=SENR on UALTAMTS                                        Page   31
Listing of STIOUT at 03:52:35 on FEB  5, 1988 for CCid=BENR on UALTAMTS                                Page   22
      775.34   775.43   775.53   775.63   775.74   775.84   776.00   776.23   776.57   777.11
      776.04   776.34   780.86   781.99   783.21   784.64   785.95   787.31   788.10   788.30
    LAYER  20
      761.84   761.74   762.64   763.87   765.20   766.53   767.86   769.18   770.50   771.80
      772.73   773.27   773.51   773.63   773.89   774.10   774.20   774.30   774.40   774.50
      774.59   774.69   774.78   774.91   775.08   775.23   775.42   775.64   775.84   776.09
      776.40   776.65   776.88   777.07   777.26   777.41   777.56   777.71   777.80   777.90
      777.99   778.09   778.19   778.29   778.38   778.50   778.66   778.88   779.22   779.78
      780.69   781.99   783.31   784.63   785.96   787.29   788.62   789.95   790.75   790.85
   ......................................................................................
                                      WATER POTENTIALS
   ......................................................................................

    LAYER   1
      600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.50   607.63   608.72
      609.51   609.97   610.28   610.46   610.59   610.66   610.75   610.85   610.93   611.02
      611.10   611.17   611.25   611.38   611.51   611.64   611.80   611.96   612.15   612.37
      612.53   612.65   613.02   613.20   613.36   613.49   613.64   613.75   613.83   613.90
      613.88   614.07   614.15   614.24   614.32   614.41   614.55   614.74   615.03   615.49
      616.26   617.36   618.50   619.63   620.76   621.89   623.02   624.15   624.83   626.00
    LAYER   2
      600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.50   607.63   608.72
      609.52   609.96   610.27   610.46   610.59   610.66   610.77   610.86   610.94   611.02
      611.10   611.16   611.26   611.37   611.51   611.65   611.81   611.98   612.15   612.37
      612.53   612.65   613.01   613.19   613.35   613.49   613.63   613.74   613.82   613.90
      613.88   614.06   614.15   614.23   614.32   614.41   614.54   614.73   615.02   615.46
      616.26   617.36   618.50   619.63   620.76   621.89   623.02   624.15   624.83   626.00
    LAYER   3
      600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.50   607.63   608.73
      609.54   610.01   610.31   610.50   610.64   610.73   610.82   610.91   610.99   611.08
      611.16   611.24   611.31   611.42   611.58   611.70   611.85   612.02   612.18   612.38
      612.82   612.82   612.98   613.15   613.30   613.44   613.56   613.69   613.76   613.84
      613.52   614.01   614.09   614.18   614.27   614.36   614.50   614.69   614.99   615.48
      616.27   617.36   618.50   619.63   620.76   621.89   623.02   624.15   624.83   626.00
    LAYER   4
      600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.50   607.63   608.75
      609.59   610.08   610.38   610.58   610.74   610.83   610.93   611.02   611.10   611.18
      611.27   611.35   611.43   611.54   611.67   611.79   611.93   612.09   612.22   612.40
      612.60   612.76   612.91   613.07   613.21   613.33   613.46   613.57   613.65   613.73
      613.61   613.90   613.98   614.07   614.17   614.26   614.41   614.61   614.93   615.41
      616.24   617.37   618.50   619.63   620.76   621.89   623.02   624.15   624.83   626.00
    LAYER   5
      600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.64   608.76
      609.65   610.18   610.50   610.73   610.89   610.99   611.09   611.19   611.29   611.37
      611.46   611.54   611.61   611.72   611.84   611.95   612.07   612.18   612.30   612.42
      612.55   612.70   612.81   612.93   613.05   613.18   613.28   613.39   613.46   613.54
      613.63   613.71   613.81   613.91   614.01   614.11   614.27   614.50   614.84   615.35
      616.22   617.36   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
    LAYER   6
      600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.80
      609.65   610.24   610.61   610.86   611.05   611.17   611.29   611.40   611.50   611.60
      611.65   611.77   611.84   611.94   612.04   612.13   612.22   612.30   612.37   612.45
      612.55   612.63   612.70   612.76   612.87   612.96   613.08   613.18   613.23   613.31
      613.40   613.50   613.60   613.71   613.83   613.95   614.14   614.39   614.78   615.31
      616.20   617.36   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
    LAYER   7
      600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.80
      609.71   610.27   610.66   610.93   611.14   611.27   611.40   611.52   611.64   611.74
      611.84   611.92   611.98   612.07   612.16   612.23   612.30   612.36   612.41   612.47
      612.53   612.59   612.64   612.70   612.77   612.84   612.93   613.02   613.08   613.16
      613.26   613.36   613.48   613.60   613.73   613.86   614.07   614.34   614.73   615.28
      616.20   617.36   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
    LAYER   8
      600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.81
      609.71   610.29   610.69   610.97   611.19   611.33   611.47   611.61   611.73   611.84
      611.93   612.01   612.07   612.15   612.23   612.28   612.34   612.40   612.43   612.48
      612.53   612.57   612.60   612.66   612.71   612.77   612.85   612.93   612.99   613.07
      613.16   613.27   613.39   613.53   613.67   613.81   614.03   614.31   614.71   615.29
      616.19   617.36   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
    LAYER   9
      600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.81
      609.72   610.30   610.72   611.01   611.24   611.39   611.55   611.70   611.83   611.95
      612.04   612.12   612.17   612.24   612.31   612.35   612.39   612.43   612.46   612.48
      612.52   612.54   612.57   612.61   612.65   612.69   612.76   612.83   612.88   612.98
      613.06   613.17   613.30   613.45   613.61   613.76   613.99   614.28   614.70   615.28
      616.19   617.36   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
    LAYER  10
      600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.81
      609.73   610.31   610.74   611.04   611.29   611.46   611.63   611.80   611.95   612.08
      612.17   612.24   612.29   612.34   612.38   612.42   612.44   612.47   612.48   612.49
      612.51   612.52   612.53   612.56   612.58   612.61   612.66   612.71   612.76   612.83
      612.93   613.04   613.20   613.37   613.54   613.71   613.96   614.26   614.68   615.27
      616.19   617.36   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
    LAYER  11
      600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.81
      609.73   610.32   610.75   611.06   611.32   611.50   611.70   611.89   612.07   612.20
      612.26   612.35   612.38   612.41   612.46   612.47   612.48   612.49   612.49   612.50
      612.50   612.51   612.51   612.52   612.53   612.54   612.59   612.62   612.65   612.72
      612.80   612.93   613.11   613.30   613.50   613.66   613.94   614.25   614.66   615.27
      616.19   617.36   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
    LAYER  12
      600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.81
      609.73   610.32   610.75   611.07   611.34   611.53   611.74   611.96   612.16   612.30
      612.36   612.43   612.45   612.46   612.48   612.49   612.49   612.49   612.49   612.50
      612.50   612.51   612.51   612.51   612.51   612.52   612.54   612.55   612.57   612.64
      612.70   612.84   613.04   613.26   613.47   613.65   613.93   614.24   614.66   615.27
      616.19   617.36   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
    LAYER  13
      600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.82
      609.73   610.33   610.76   611.08   611.36   611.56   611.78   612.03   612.27   612.41
      612.44   612.46   612.46   612.46   612.48   612.49   612.49   612.49   612.49   612.50
      612.50   612.51   612.51   612.51   612.51   612.52   612.52   612.53   612.53   612.56
      612.63   612.73   612.97   613.22   613.44   613.64   613.93   614.24   614.67   615.27
      616.18   617.36   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
    LAYER  14
      600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.82
      609.74   610.33   610.77   611.09   611.37   611.57   611.81   612.10   612.39   612.46
      612.46   612.46   612.46   612.46   612.48   612.49   612.49   612.49   612.49   612.50
      612.50   612.51   612.51   612.51   612.51   612.52   612.52   612.52   612.52   612.53
      612.52   612.61   612.90   613.19   613.43   613.63   613.91   614.23   614.67   615.26
      616.18   617.36   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
    LAYER  15
      600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.82
      609.74   610.33   610.77   611.09   611.37   611.58   611.83   612.17   612.46   612.48
      612.46   612.46   612.46   612.46   612.48   612.49   612.49   612.49   612.49   612.50
      612.50   612.51   612.51   612.51   612.51   612.52   612.52   612.52   612.52   612.52
      612.52   612.52   612.83   613.17   613.42   613.63   613.91   614.23   614.67   615.26
      616.18   617.36   618.49   619.63   620.76   621.89   623.02   624.15   624.83   626.00
    LAYER  16
      600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.82
      609.74   610.33   610.77   611.09   611.37   611.58   611.83   612.17   612.46   612.48
      612.46   612.46   612.46   612.46   612.48   612.49   612.49   612.49   612.49   612.50
      612.50   612.51   612.51   612.51   612.51   612.52   612.52   612.52   612.52   612.52
      612.52   612.52   612.83   613.17   613.42   613.63   613.91   614.23   614.67   615.26
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Listing of S71OUT at 02:52:35 on FEB  5, 1988 for CC1d=BENR on UALTAMTS                                   Page   23
2729     616.16   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   625.00
2730    LAYER  17
2731     600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.82
2732     609.74   610.23   610.77   611.09   611.27   611.57   611.81   612.10   612.39   612.48
2733     612.48   612.46   612.46   612.48   612.48   612.49   612.49   612.49   612.49   612.50
2734     612.50   612.51   612.51   612.51   612.51   612.52   612.52   612.52   612.53   612.53
2735     612.53   612.51   612.90   613.19   613.43   613.83   613.91   614.23   614.87   615.28
2736     616.16   617.25   618.49   619.63   620.76   621.89   623.02   624.15   624.83   625.00
2737    LAYER  18
2738     600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.82
2739     609.73   610.32   610.76   611.06   611.30   611.56   611.78   612.03   612.27   612.41
2740     612.44   612.48   612.48   612.46   612.48   612.49   612.49   612.49   612.49   612.50
2741     612.50   612.51   612.51   612.51   612.51   612.52   612.52   612.52   612.52   612.58
2742     612.59   612.73   612.97   613.22   613.44   613.84   613.92   614.24   614.87   615.27
2743     616.16   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   625.00
2744    LAYER  19
2745     600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.81
2746     609.73   610.32   610.76   611.07   611.34   611.53   611.74   611.98   612.16   612.30
2747     612.36   612.43   612.45   612.46   612.48   612.49   612.49   612.48   612.49   612.50
2748     612.50   612.51   612.51   612.51   612.51   612.52   612.54   612.55   612.57   612.64
2749     612.70   612.84   613.04   613.26   613.47   613.66   613.83   614.24   614.66   615.27
2750     616.19   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   625.00
2751    LAYER  20
2752     600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.81
2753     609.73   610.32   610.75   611.06   611.32   611.50   611.70   611.89   612.07   612.20
2754     612.28   612.35   612.38   612.41   612.46   612.47   612.46   612.49   612.48   612.50
2755     612.50   612.51   612.51   612.52   612.53   612.54   612.59   612.62   612.65   612.72
2756     612.80   612.93   613.11   613.30   613.50   613.68   613.94   614.25   614.58   615.27
2757     616.19   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   625.00
2758    LAYER  21
2759     600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.81
2760     609.73   610.21   610.74   611.04   611.28   611.48   611.63   611.80   611.96   612.08
2761     612.17   612.24   612.28   612.34   612.39   612.42   612.44   612.47   612.48   612.49
2762     612.51   612.52   612.53   612.56   612.56   612.61   612.66   612.71   612.75   612.83
2763     612.82   613.04   613.20   613.37   613.54   613.71   613.96   614.26   614.81   615.27
2764     616.19   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   625.00
2765    LAYER  22
2766     600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.81
2767     609.72   610.20   610.72   611.01   611.24   611.39   611.55   611.70   611.83   611.95
2768     612.04   612.12   612.17   612.24   612.31   612.36   612.39   612.43   612.46   612.48
2769     612.52   612.54   612.57   612.61   612.65   612.69   612.78   612.83   612.86   612.99
2770     613.05   613.17   613.30   613.45   613.61   613.76   613.99   614.28   614.70   615.28
2771     616.19   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   625.00
2772    LAYER  23
2773     600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.81
2774     609.71   610.28   610.69   610.97   611.19   611.33   611.47   611.61   611.73   611.84
2775     611.93   612.01   612.07   612.15   612.23   612.29   612.34   612.40   612.43   612.48
2776     612.62   612.57   612.60   612.66   612.71   612.77   612.85   612.93   612.98   613.07
2777     613.16   613.27   613.39   613.53   613.67   613.81   614.03   614.31   614.71   615.29
2778     616.19   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   625.00
2779    LAYER  24
2780     600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.80
2781     609.71   610.27   610.66   610.93   611.14   611.27   611.40   611.52   611.64   611.74
2782     611.84   611.92   611.98   612.07   612.16   612.23   612.30   612.36   612.41   612.47
2783     612.53   612.59   612.64   612.70   612.77   612.84   612.93   613.02   613.09   613.16
2784     613.26   613.38   613.48   613.60   613.73   613.86   614.07   614.34   614.73   615.28
2785     616.20   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   625.00
2786    LAYER  25
2787     600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.65   608.80
2788     609.69   610.24   610.61   610.86   611.05   611.17   611.29   611.40   611.50   611.60
2789     611.69   611.77   611.84   611.94   612.04   612.13   612.22   612.30   612.37   612.45
2790     612.55   612.63   612.70   612.78   612.87   612.96   613.06   613.16   613.22   613.31
2791     613.40   613.50   613.60   613.71   613.83   613.95   614.16   614.39   614.76   615.31
2792     616.20   617.35   618.49   619.63   620.76   621.89   623.02   624.15   624.83   625.00
2793    LAYER  26
2794     600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.51   607.64   608.78
2795     609.65   610.16   610.50   610.73   610.89   610.99   611.09   611.19   611.29   611.37
2796     611.48   611.54   611.61   611.72   611.84   611.95   612.07   612.19   612.30   612.42
2797     612.56   612.70   612.81   613.03   613.08   613.16   613.26   613.38   613.46   613.54
2798     613.63   613.71   613.81   613.91   614.01   614.11   614.27   614.50   614.84   615.38
2799     616.22   617.30   618.49   619.63   620.76   621.89   623.02   624.15   624.83   625.00
2800    LAYER  27
2801     600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.50   607.63   608.76
2802     609.59   610.08   610.39   610.59   610.74   610.83   610.93   611.02   611.10   611.19
2803     611.27   611.35   611.43   611.54   611.67   611.79   611.93   612.09   612.22   612.40
2804     612.60   612.74   612.91   613.07   613.21   613.33   613.46   613.57   613.66   613.73
2805     613.81   613.90   613.98   614.07   614.17   614.26   614.41   614.61   614.93   615.41
2806     616.24   617.37   618.50   619.63   620.76   621.89   623.02   624.15   624.83   625.00
2807    LAYER  28
2808     600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.50   607.62   608.73
2809     609.54   610.01   610.31   610.50   610.64   610.73   610.82   610.91   610.99   611.08
2810     611.16   611.24   611.31   611.42   611.56   611.70   611.86   612.02   612.18   612.38
2811     612.62   612.82   612.98   613.15   613.30   613.44   613.56   613.68   613.76   613.84
2812     613.92   614.01   614.08   614.18   614.27   614.35   614.50   614.68   614.99   615.48
2813     616.27   617.36   618.50   619.63   620.76   621.89   623.02   624.15   624.83   625.00
2814    LAYER  29
2815     600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.50   607.62   608.73
2816     609.52   609.98   610.27   610.46   610.59   610.68   610.77   610.86   610.94   611.02
2817     611.10   611.18   611.26   611.37   611.51   611.66   611.81   611.99   612.15   612.37
2818     612.63   612.85   613.01   613.19   613.35   613.48   613.63   613.74   613.82   613.90
2819     613.98   614.06   614.15   614.23   614.32   614.41   614.54   614.73   615.02   615.48
2820     616.28   617.38   618.50   619.63   620.76   621.89   623.02   624.15   624.83   625.00
2821    LAYER  30
2822     600.00   600.17   600.85   601.98   603.11   604.24   605.37   606.50   607.62   608.73
2823     609.51   609.97   610.26   610.45   610.59   610.66   610.75   610.85   610.93   611.02
2824     611.10   611.17   611.25   611.36   611.51   611.64   611.80   611.98   612.15   612.37
2825     612.63   612.85   613.02   613.20   613.36   613.49   613.64   613.75   613.83   613.90
2826     613.98   614.07   614.16   614.24   614.32   614.41   614.55   614.74   615.03   615.48
2827     616.28   617.38   618.50   619.63   620.76   621.89   623.02   624.15   624.83   625.00
2828    EOI ENCOUNTERED.
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Appendix 4

Sample calculation - fluid pressure to hydraulic head.

Consider 2 points at the upstream boundary of the flow domain. Both points have water hydraulic heads equal to 625 metres. The upper point (at zero elevation), has a water pressure of 6 125 kPa and the lower point, (295 metres below) has a water pressure of 9 016 kPa. Neglecting capillary forces, (for now) each of these water pressures are converted to hydraulic heads (equation 2.3) by dividing by the specific weight of the oil (8330 $kg/m^2/s^2$). This yields 735.29 and 787.35 metres of oil hydraulic head for the upper and lower points, respectively. Then, a capillary pressure equivalent of 3.6 metres is added, to yield hydraulic heads of 738.89 and 790.95 metres, for the upper and lower points. These are the values observed in Figure 6.4 and in Appendix 3, column 60, layers 1 and 30.